Electronic Services - Hayward, Ca
M17406X

INSTRUCTION MANUAL
MODEL 106A
PULSE GENERATOR

DATAPULSE

INSTRUCTION MANUAL

MODEL 106A

PULSE GENERATOR

The Model 106A is an all solid state, medium power pulse generator ideally suited for advanced laboratory, production line, or other testing applications.

This instrument features 12mc repetition rate, with stimulated rate of 20mc on Double Pulse Mode, independently variable rise and decay time, and wide range control over all major pulse parameters. Regulated power supplies insure low jitter and stable operations under fluctuating line voltage.

This manual contains general and detailed instructions for operation and maintenance of your Model 106A Pulse Generator. A complete understanding of its contents will contribute greatly to full utilization of the broad capabilities of this instrument.

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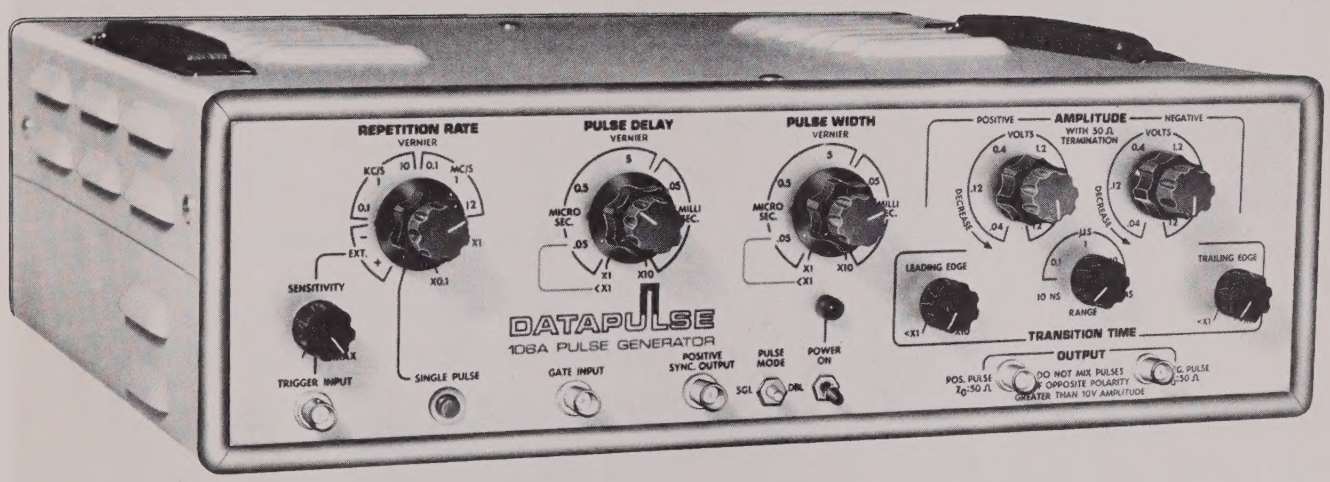

MODEL 106A PULSE GENERATOR

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ABBREVIATIONS - SYMBOLS - TERMINOLOGY

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SECTION I

SPECIFICATIONS

1.1 REPETITION RATE

Continuously variable from 10 cps to 12 mc, covered in six decade ranges, for either Single Pulse or Double Pulse Mode. Effective rep rates to 20 mc may be set up in the Double Pulse Mode by proper positioning of the second pulse.

1.2 EXTERNAL TRIGGER

Operates at 0 to 12 mc from ±5 v pulses (30 nanosec. min. duration) or at 10 cps to 10 mc from 4 v rms sine waves. Polarity and sensitivity controls provide for reliable triggering at any point on the input waveform more than 5 v above or below its average dc level. Input impedance is 5000 ohms. Maximum dc level or transient amplitude which may be applied is ±10 v with sensitivity control at maximum.

1.3 SINGLE PULSE

Operation of a front panel pushbutton provides one cycle of output.

1.4 GATED OPERATION

External gate signal levels more pos. than neg. 1 v block main pulse outputs, no connection or levels below neg. 5 v enable outputs. Gate signal must furnish approx. 6 ma to gate input. Levels greater than ±10 v may not be applied.

1.5 SYNC OUTPUTS

Pos. 5 v pulse into 100 ohms, approx. 50 nanosec. duration and 20 nanosec. rise time, ac coupled. Sync Output occurs approx. 50 nanosec. after triggering point of external trigger, if used.

a) Amplitude is greater than 5.5 v into 1000 ohms from 10 cps to 12 mc.

b) Amplitude is greater than 5 v into 100 ohms from 10 cps to 4 mc.

c) Amplitude is greater than 3.8 v into 100 ohms from 4 mc to 12 mc.

1.6 PULSE MODES

Single Pulse or Double Pulse, selected by panel toggle switch. In the Double Pulse Mode, two main pulses are provided at the output during each cycle (identical in width, amplitude, polarity, rise time, and fall time), one approx. coincident with the Sync Output and the second at a position determined by the pulse delay controls.

1.6.1 Pulse Delay, Single Pulse Mode (of min. rise time leading edge from Sync Output)

Continuously variable from less than 40 nanosec. to 5 millisec., covered in five decade ranges. Max. delay duty cycle is greater than 50%.

1.6.2 First Pulse Position, Double Pulse Mode:

Min. rise time leading edge occurs approx. 10 nanosec. before Sync Output.

1.6.3 Pulse Separation, Double Pulse Mode:

Leading edge of first pulse to leading edge of second pulse is continuously variable, by means of Pulse Delay controls, from less than 50 nanosec. to 5 millisec. Min. trailing edge to leading edge separation is approx. 30% of pulse width or 25 nanosec., whichever is greater (pulse narrows at lesser separations).

1.7 PULSE DURATION (at 50% point of min. rise and fall time waveform)

Continuously variable from less than 25 nanosec. to 5 millisec., covered in five decade ranges.

1.8 JITTER AND ACCURACY

Jitter is less than 0.1%. Full scale of each range is nominally accurate within ±5% (±7% max.).

1.9 MAIN PULSE OUTPUT

Pos. and neg. outputs are provided simultaneously. Outputs are dc coupled with base line at ground, source impedance is constant at 50 ohms.

1.9.1 Peak Amplitude (Separately Controlled for Pos. and Neg. Outputs)

Continuously variable from 10 mv to 12 v into 50 ohms, covered in six ranges (1, 3, 10 sequence) plus fill-in.

1.9.2 Rise and Fall Times (Controlled Simultaneously for Pos. and Neg. Outputs)

With 50 ohm resistive load, continuously variable from 10 nanosec. to 1 millisec. (10 to 90% points), covered in five decades by a common control plus separate fill-in controls for rise and fall time. The transition times are linear* within ±10%. Pos. and neg. output transition times track each other within approx. 15 nanosec. when set at minimum.

1.9.3 Waveform Aberrations (with Properly Connected 50 Ohm Load)

Overshoot, undershoot, ring, and top slope are typically less than ±2% (±4% max.), at amplitudes greater than 300 mv.

1.9.4 Output Protection

Automatic scaling and amplitude reduction occur at duty cycles greater than approx. 70%. Output stages will withstand short circuits of any duration without detrimental effects, and will tolerate back voltages up to ±10 v.

*Transition time linearity is referenced to the best straight line drawn between the 10% and 90% amplitude points.

1.10 MIXING OUTPUTS

Pos. and neg. outputs of multiple units may be mixed with each other or with other outputs (±10 v max.) by connecting directly to a common 50 ohm load returned to ground. Maximum non-superimposed output when so connected is approximately 10 v. Superimposed outputs add approx. algebraically to a maximum of 10 v.

1.11 OPERATING TEMPERATURE

The unit is rated for operation with ambient temperature from 0 to 50°C.

1.12 POWER REQUIRED

105-125 v, 50/60 cycle ac, approx. 70 watts. 220 v operation may be specified at no added cost.

1.13 CONSTRUCTION

Aluminum panel with etched red and black markings, beige cabinet with quick-release top and bottom covers, BNC connectors.

1.14 SIZE AND WEIGHT

5-1/4"h x 17"w x 15-1/4"d, approx. 25 lbs. May be rack mounted (5-1/4"h x 19"w panel space) by specifying Model 106AR or by installing Type 1003 rack mounting set.

1.15 ACCESSORIES FURNISHED

One operation and maintenance manual, 8 ft. line cord with NEMA 3-prong plug.

1.16 ACCESSORIES AVAILABLE

Extra instruction manual copies, 50 ohm 15 watt termination (Type 2002A), inverting pulse transformer (Type 2101) for providing neg. sync output, rack mounting set (Type 1003), BNC 50 ohm coaxial cables.

OPERATING INSTRUCTIONS

2.1 DESCRIPTION OF CONTROLS AND CONNECTORS

2.1.1 Power ON Switch

Connects or disconnects ac input voltage to transformer primaries within instrument.

2.1.2 Pilot Lamp

Lights when power is on.

2.1.3 Repetition Rate

The black outer knob selects the repetition rate range. There are six ranges each covering one decade of frequency. One position is provided for single pulse operation and one position for external triggering with positive going waveforms and one position for triggering with negative going waveforms.

2.1.4 Repetition Rate Vernier

The red inner knob provides continuous fill-in between ranges of the repetition rate control. With this control fully clockwise, the instrument is calibrated at the frequency shown by the repetition rate control.

2.1.5 Single Pulse Button

Each depression of the button initiates one cycle of output when repetition rate control is in single pulse position.

2.1.6 Pulse Mode Switch

Single Pulse or Double Pulse, selected by panel toggle switch. In the Double Pulse Mode, two main pulses are provided at the output during each cycle (identical in width, amplitude, polarity, rise time, and fall time), one approx. coincident with the Sync Output and the second at a position determined by the pulse delay controls.

2.1.6.1 Pulse Delay, Single Pulse Mode (of min. rise time leading edge from Sync Output): Continuously variable from less than 40 nanosec. to 5 millisec., covered in five decade ranges. Max. delay duty cycle is greater than 50%.

2.1.6.2 First Pulse Position, Double Pulse Mode: Min. rise time leading edge occurs approx. 10 nanosec. before Sync Output.

2.1.6.3 Pulse Separation, Double Pulse Mode: Leading edge of first pulse to leading edge of second pulse is continuously variable, by means of Pulse Delay controls, from less than 50 nanosec. to 5 millisec. Min. trailing edge to leading edge separation is approx. 30% of pulse width or 25 nanosec., whichever is greater (pulse narrows at lesser separations).

2.1.7 External Trigger Input Jack

BNC connector which accepts a pulse or sine wave to slave oscillator to outside signal when repetition rate control is in EXT.

2.1.8 External Sensitivity

Adjusts the level on an external signal at which the oscillator triggers.

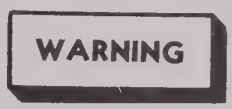
Maximum allowable input signal is ±10 v when sensitivity control is in maximum position.

2.1.9 Positive Sync Output

This BNC connector provides a 6 v positive pulse output on each cycle which serves as a "0" time reference for the delay circuit.

2.1.10 Gate Input

This BNC connector provides input for an external gating signal. When dc level of signal is more positive than -1 v, output pulses are disabled.



Maximum is ±10 v.

2.1.11 Pulse Delay

The black outer knob selects the delay range. There are five ranges, each covering one decade.

2.1.12 Pulse Delay Vernier

The red inner knob provides continuous fill-in between ranges of the pulse delay control. With this control fully ccw the instrument is calibrated at the delay shown by the Pulse Delay control.

2.1.13 Pulse Width

The black outer knob selects the width range. There are five ranges each covering one decade.

2.1.14 Pulse Width Vernier

The red inner knob provides continuous fill-in between ranges of the Pulse Width control. With this control fully ccw the instrument is calibrated at the width shown by the Pulse Width Control.

2.1.15 Transition Time Range

This control determines the range of output pulse transition times. There are five ranges, each covering one decade.

2.1.16 Leading Edge Transition Time

This control provides continuous variation of leading edge transition time within the range set

by the transition time range control.

2.1.17 Trailing Edge Transition Time

This control provides continuous variation of trailing edge transition time within the range set by the transition time range control.

2.1.18 Positive Pulse Amplitude

The black outer knob sets the output voltage range. There are six ranges following a one, three, ten pattern, calibrated in volts when output is terminated with 50 ohms.

2.1.19 Positive Pulse Amplitude Vernier

The red inner knob provides continuous fill-in between positions of the positive pulse amplitude control. When this control is in the fully clockwise position the instrument is calibrated at the setting of the positive pulse amplitude control.

2.1.20 Positive Pulse Output

This BNC connector couples the variable parameter pulse to an external load.

2.1.21 Neg. Pulse Amplitude

The black outer knob sets the output voltage range. There are six ranges following a one, three, ten pattern. Calibrated in volts when output is terminated with 50 ohms.

2.1.22 Neg. Pulse Amplitude Vernier

The red inner knob provides continuous fill-in between positions of the neg. pulse amplitude control. When this control is in the full clockwise position, the instrument is calibrated at the setting of the negative pulse amplitude control.

2.1.23 Neg. Pulse Output

This BNC connector couples the variable parameter pulse to an external load.

2.1.24 Fuse (located on rear panel)

One amp fast blow fuse protects against ac overload.

2.1.25 Power Input (located on rear panel)

This 3-prong recessed male connector accepts a NEMA 3-wire line cord to supply ac power from the line.

2.2 PLACING IN OPERATION

2.2.1 Preliminary Settings

a. Set REPETITION control to 0.1mc, VERNIER cw.
b. Set PULSE MODE switch to single pulse position.
c. Set PULSE DELAY control to 0.05μs, VERNIER ccw.
d. Set PULSE WIDTH control to 0.05μs, VERNIER cw.
e. Set TRANSITION TIME control to 10ns, VERNIER midscale.
f. Set ATTENUATORS to 10v, VERNIER cw.
g. Load Outputs into 50 ohms.
h. Set POWER switch to ON. PILOT SHOULD LIGHT.
i. Sync scope from POSITIVE SYNC OUTPUT. Set scope sweep to 0.1μs/cm vertical sensitivity to 5v/cm.
j. View positive output pulse against that shown in Figure 2-1.

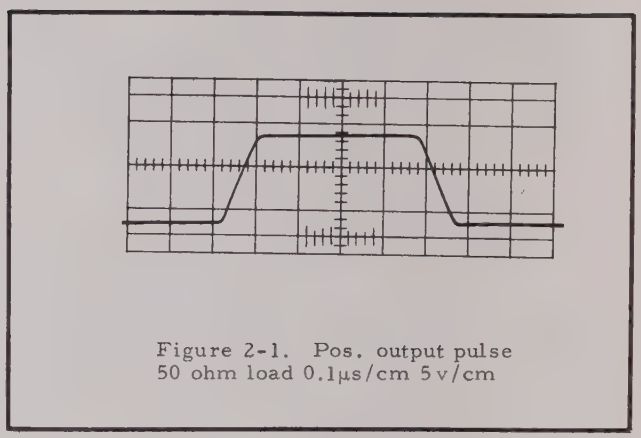


Figure 2-1. Pos. output pulse 50 ohm load 0.1μs/cm 5v/cm

k. View negative output pulse against that shown in Figure 2-2.

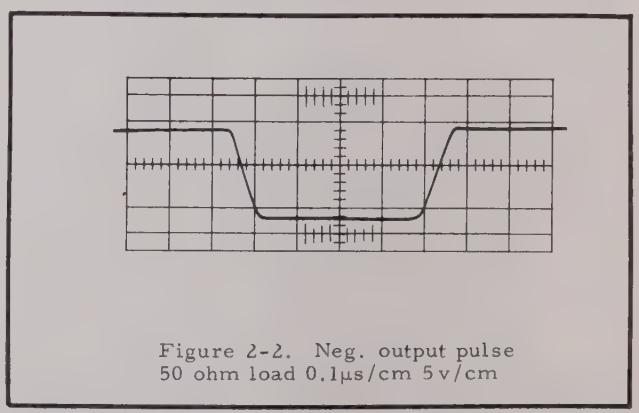


Figure 2-2. Neg. output pulse 50 ohm load 0.1μs/cm 5v/cm

l. If instrument fails to function properly, refer to paragraph 4.3.

2.3 OPERATING CONSIDERATIONS

2.3.1 External Triggering

When the repetition rate control is in the EXT - for EXT + position, the Model 106A can be driven from an external source provided that the driving signal is greater than 5v in amplitude and greater than 35 nanoseconds in width. As the synchronizing circuit is a Schmitt trigger with 10 cps frequency response, the slope and rise time of the driving waveform is not critical. In EXT - position the circuit will trigger on the negative going slope of the input waveform, and the EXT + position the circuit triggers on the positive going slope.

When externally driving the Model 106A, always set the sensitivity control to the full counter-clockwise on minimum position before application of the driving waveform. This will insure that no damage will be done to the Schmitt trigger should the driving waveform be greater than ±10v in amplitude. With the external signal applied to the external trigger input jack and the sensitivity control in the minimum position, adjust the sensitivity clockwise until stable triggering is obtained. Do not advance the sensitivity control any more than is necessary as the lowered input impedance and attendant overdrive may cause severe distortion of the input signal which can result in unstable multiple triggering of the Model 106A.

WARNING

Always insure that the driving signal is less than ±10v when the sensitivity control is in the maximum (clockwise) position to avoid damage to the Schmitt trigger circuit.

As the input to the synchronizing circuit is ac coupled, the reference level presented will vary as a function of the duty cycle and/or amplitude of the driving waveform. Therefore, when either of these parameters are changed, the sensitivity control must be readjusted to provide triggering at the same point on the input signal.

2.3.2 Duty Cycle Limitations

At duty cycles greater than 70%, the pulse delay and width one shot multivibrators may fail. There are no average current or power limitations imposed on the Model 106A; however, under excessive duty cycle conditions instability and severe amplitude reductions occur. In order to minimize confusion and inaccurate data which will most certainly result from excessive duty cycle, it is recommended that the delay and width controls be set to their minimum position when frequency is being changed, and then reset to the desired settings upon completion of frequency shift. In this manner it is highly improbable that duty cycle rating will be exceeded while the frequency control is adjusted.

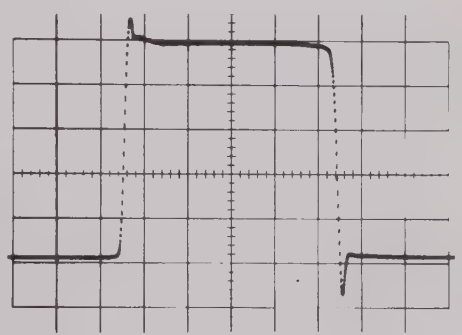
2.3.3 Transition Time Control

The Model 106A features an extremely versatile rise and decay time control. The leading and trailing edge transition times may be independently varied over a range of greater than 10:1. In addition, both edges are linear to within ±10% as measured from the best straight line between the 10% and 90% amplitude points. This feature virtually eliminates errors which usually creep in during setting up of rise and decay for a particular test, insuring repeatability of results and consistent data from test to test.

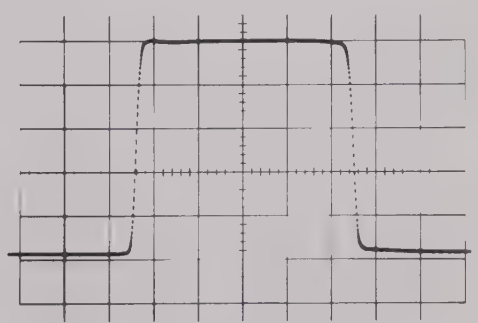
The transition time range control varies both the rise and decay times simultaneously in decade steps from less than 10 ns to greater than 1 ms. The transition time leading edge and trailing edge controls are independent and provide continuous fill-in within a transition time range. With this form of control it is possible to produce waveforms with leading edge transition time differing from trailing edge transition time by a ratio of greater than 10 : 1, enabling the Model 106A to generate useful functions such as ramps, sawteeth, triangles and trapezoids, where required.

2.3.4 Output Characteristics

2.3.4.1 Amplitude Control: The outputs of the current drivers are coupled to their respective BNC connectors by the use of constant impedance attenuators. Each output has an independent attenuator providing over 60db attenuation in 10db steps, plus an uncalibrated fill-in control capable of over 20db. For minimum distortion of output pulses, however, the fill-in control should not be adjusted to give over 10db (1/3 amplitude). See Figure 2-3. The attenuators are calibrated in volts rather than db to provide faster interpretation of dial readings.



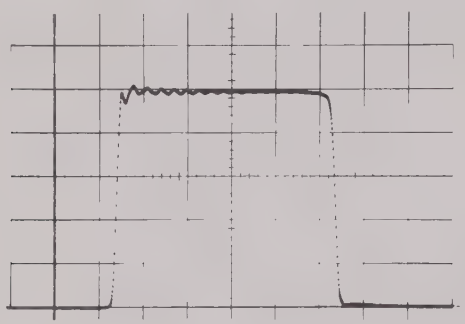
(a) Pos Output Pulse Attenuated to 1v(20db)Using Fill-in Control only.



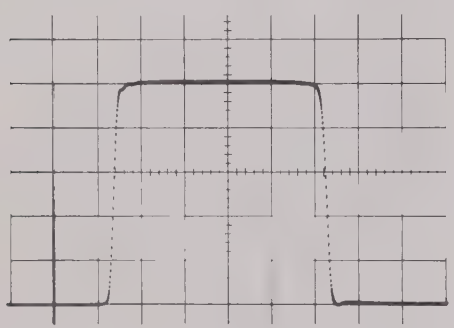
(b) Pos Output Pulse Attenuated to 1v(20db)Using Step Attenuation only.

Figure 2-3. Photographed from Hewlett-Packard, Model 185B Sampling Oscilloscope 50 nanoseconds/cm 0.2v/cm.

2.3.4.2 Loading of Idle Output: Because of the fast rise times involved, the current amplifiers have a tendency to radiate when unloaded. When only one output is being used at rise times faster than 25 ns, it will be necessary to load the idle output with 50 ohms to prevent ringing on the output pulse due to radiation. The most convenient method of loading the idle output is to set the attenuator to the 0.3v position as the attenuator has a characteristic impedance of 50 ohms, at rise time settings of less than 15 ns, an unloaded idle output can cause distortions of greater than 2% on the output being used. See Figure 2-4. Therefore, in order to meet equipment specification with regard to pulse distortion it is mandatory that the user adheres to the instructions given above.



(a) Pos Output Pulse with Neg Output Open Circuit. Note Ring on Leading Corner



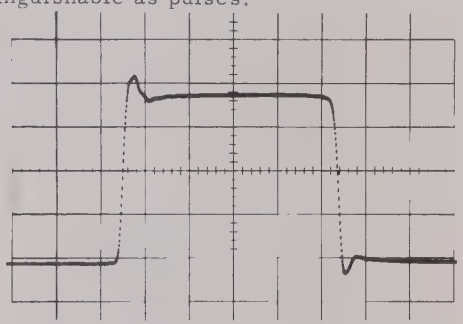
(b) Pos Output Pulse with Neg Attenuation. Set at 0.3v. Note Relative Lack of Ring

Figure 2-4. Photographed from Hewlett-Packard, Model 185B Sampling Oscilloscope 50 nanoseconds/cm 2v/cm.

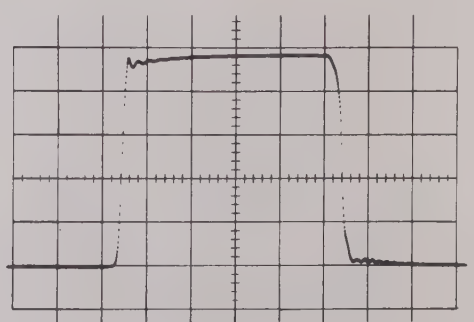
2.3.5 Loading Considerations

One of the major advantages of the Model 106A over competitive pulse generators is its clean waveforms, even at fast rise times. In order to preserve this degree of pulse fidelity, it is imperative that due consideration is given to loading. The generation of a clean waveform with rise times which are variable between the limits from 10 ns to over 1 ms requires state of the art circuit design and packaging technique. As such, it is necessary to restrict the type of loading which can be imposed upon the output stages. Because of the wide usage of 50 ohm cables and accessories in industry, the Model 106A was designed for operation with a 50 ohm load.

The output section of the Model 106 consists of a positive and a negative current amplifier each supplying 200 ma. The operating point of each amplifier is biased near saturation when supplying 200 ma into a 50 ohm load. The load impedance must not vary more than ±5% from 50 ohms if the specified overshoot and undershoot specifications are to be met. Load impedances over 50 ohms causes saturation of current amplifiers and hence, introduces storage time effects; on the other hand, load impedances less than 50 ohms increase the collector voltage of the transistors in the current amplifiers which causes overshoot and ringing (See Figure 2-5.) If the outputs are open circuited, the current amplifiers will be in deep saturation and the resultant waveform will be indistinguishable as pulses.



(a) Full Amplitude Pos Pulse Loaded into 40 ohms. Note Overshoot and Undershoot



(b) Full Amplitude Pos Pulse Loaded into 60 ohms. Note Ring and Top Slope.

Figure 2-5. Photographed from Hewlett-Packard, Model 185B Sampling Oscilloscope 50 nanoseconds/cm 2v/cm.

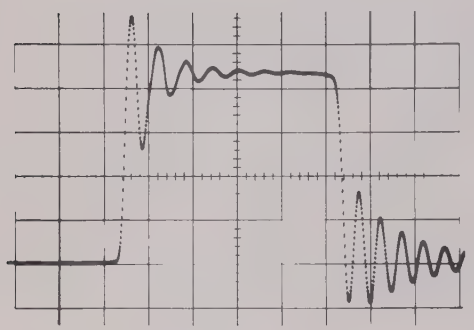
2.3.6 Cabling Considerations

In most cases the Model 106A will be used to drive loads which are physically separated from it by several feet. In this case, it will be necessary to convey the signal by means of a 50 ohm transmission

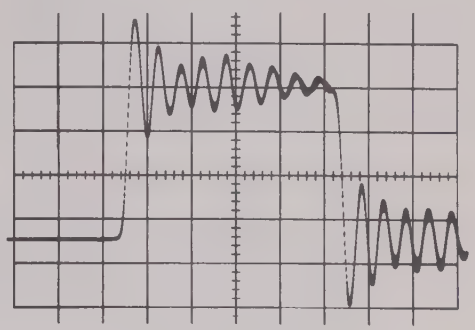
line. Preservation of low distortion waveforms is largely contingent upon the method of cabling and in proper termination of the transmission line. Clean waveforms are maintained by connecting the generator to its load with 50 ohm coaxial cable, and terminating the cable AT THE LOAD into 50 ohms. This is true of the sync connection to the scope, except 93-ohm cable and load.
Figure 2-6 illustrates the effects of poor cabling. Figure 2-7 illustrates proper cabling.

Figure 2-6

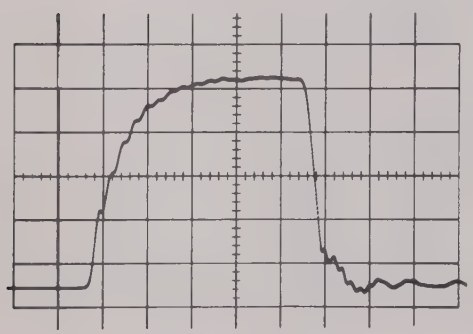
Photographed from Hewlett-Packard, Model 185 Oscilloscope
50 nanoseconds/cm, 2v/cm. (e) is 0.5 microseconds/cm



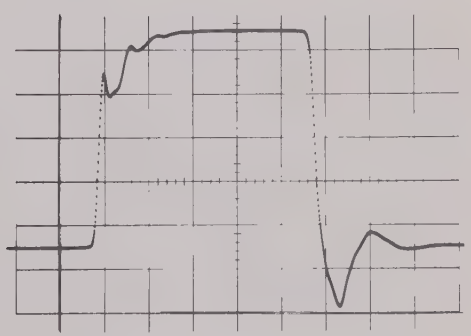
(a) Pos Pulse at End of 4-ft. RG58A/U Cable Terminated in 50 ohms at the Generator



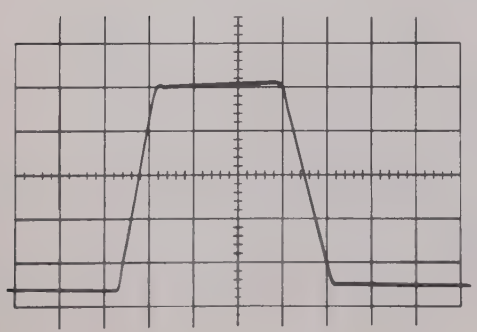
(b) Pos Pulse at End of 4-ft. Clip Leads. Terminated into 50 ohms at the Generator



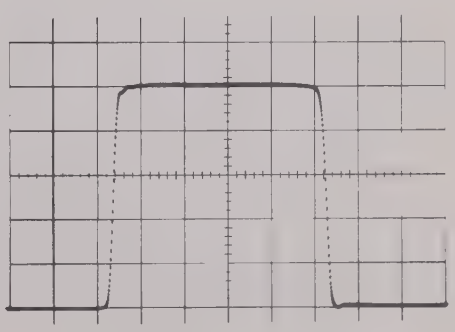
(c) Pos Pulse at End of 4-ft. Clip Leads. Terminated into 50 ohms at Scope.



(d) Pos Pulse at End of 6-ft. RG63/U(100)Cable Terminated into 50 ohms at Scope



(e) Pos. Pulse at End of 4-ft. Clip Leads. 50 ohm Load at Scope. Rise time set for approx. 0.5 μsec.



(f) Pos. Pulse through 4-ft. RG58A/U Cable Terminated in 50 ohms at Scope. (Good Technique)

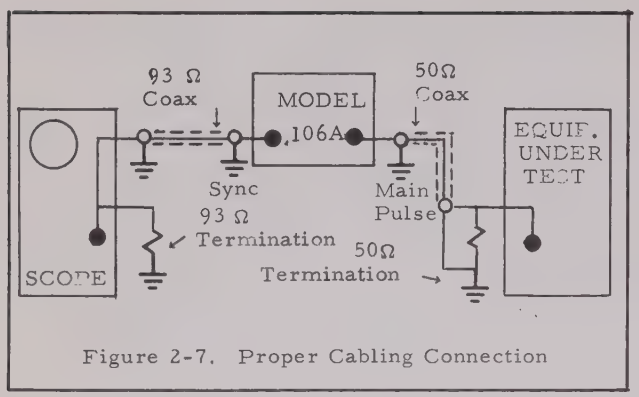


Figure 2-7. Proper Cabling Connection

2.3.7 Non-Linear Loads

In many cases, the unit will be used to drive non-linear loads such as transistors and diodes. This type of loading generally exhibits high impedance in one direction and low impedance in the other direction. Care must be taken to insure uniform loading on the unit in both directions to obtain clean waveforms. Figure 2-8 illustrates some of the methods whereby the unit could be terminated when driving into the base of a transistor. The same techniques apply when driving diodes since the base of transistor resembles a diode.

The external connections shown in Figures a, b, & c, are suggested for driving into transistor stages. In these examples the "speed up" capacitor will slow down the rise and fall times of the main output pulse. Ringing may occur if the transistor load improperly terminates the generator. It is advisable not to adjust the rise and fall time of the output any faster than is required, since load mismatch is more pronounced at this higher rise/fall frequency. These examples illustrate methods of referencing the output pulse so that the transistor will be back biased in the quiescent state.

2.3.7.1 Decoupling Output for Non-Linear Loads: When minimal pulse distortion is required and the load is non-linear, it might be necessary to decouple the Model 106A from the load by means of an emitter follower. The transistor used for the emitter follower must have the following requirements:

a. It must have the frequency response necessary to give the rise and fall times required.
b. Its input capacitance must be low in order to minimize pulse distortion.
c. It must have sufficient gain to supply the current required by the load.
d. It must have sufficient power and voltage required by the load.

The positive output should be decoupled by means of NPN transistors and the negative output should be decoupled by means of PNP transistors. The receiving end of the cable should be terminated directly into a 50 ohm resistor and the input of the emitter follower should be connected to the cable by means of a 22 ohm resistor. See Figure 2-9. The resistor is used as a parasitic suppressor and is absolutely necessary in order to minimize pulse distortion at fast rise and fall times. Of course, the operating voltages and the necessary resistors of the emitter follower are determined by the magnitudes of the voltange and current required by the load.

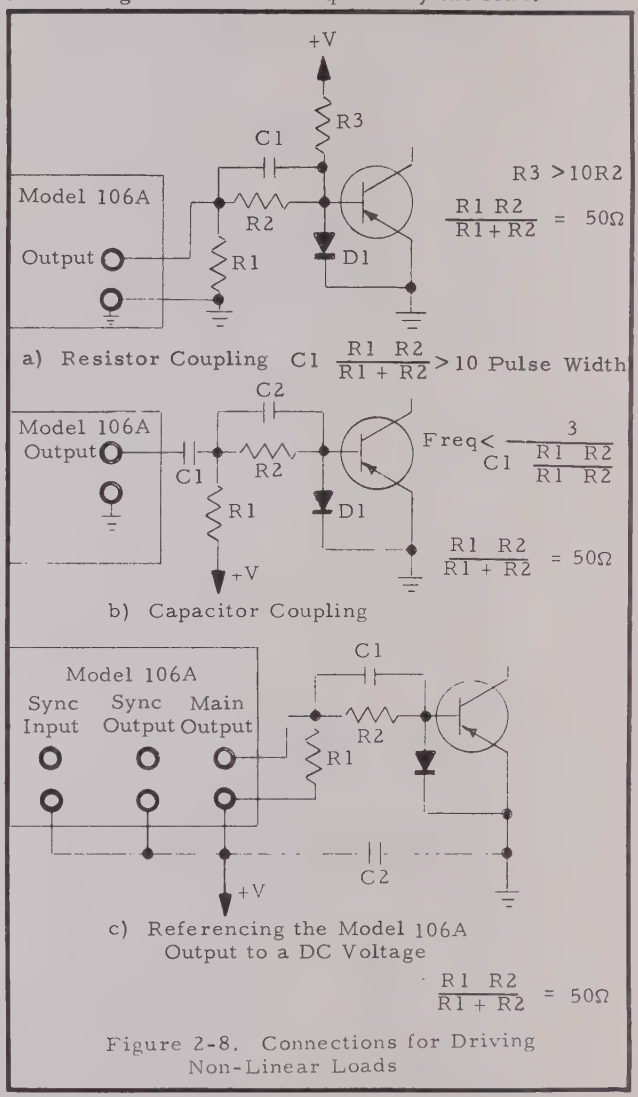


Figure 2-8. Connections for Driving Non-Linear Loads

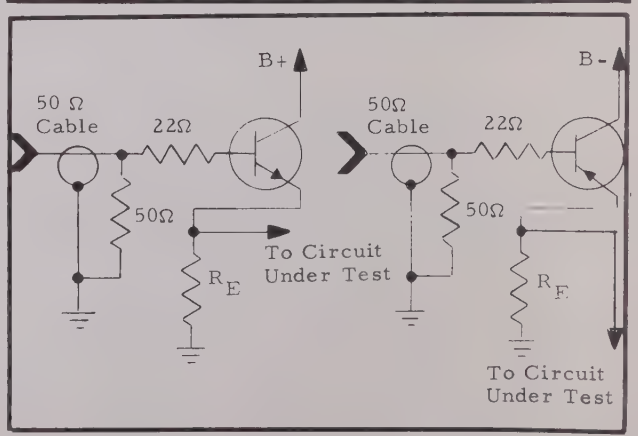


Figure 2-9. Decoupling Output for Non-Linear Loads

2.3.8 Mixing of Several Outputs

The outputs on the Model 106A may be mixed with other outputs if the common load is 50 ohms and if the amplitudes involved are less than 8 v. If the outputs of two Model 106A's are mixed, the resulting amplitudes will be one-half their unmixed value unless the attenuators of both units are in the 10 v position. The reason for this is that the output impedance of the attenuator is 50 ohms and, therefore, the resulting load in two Model 106A's in parallel working into a common 50 ohm load is 25 ohms.

Mixing the outputs in general will degrade the rise time and cause pulse distortion. This condition is usually caused by the output impedance of the units in parallel having reactive components. The transition time and the pulse distortion of the Model 106A are given only for a resistive load. Any reactive loading on the output terminal will increase the pulse distortion and the rise and fall times. Best results will be obtained when the DATAPULSE 2301 mixing network is used to tie the output together.

The use of this mixing network will cause the resulting amplitude to be one half of its unmixed value. However, pulse distortions will be minimized.

2.4 SPECIAL APPLICATIONS

2.4.1 Multiple Pulse or Pulse Train Operation Using Several Model 106As

Magnetic device testing, beacon development, and digital or other pulse code simulation often require multiple pulse or pulse train signals. Multiple Datapulse 106A Pulse Generators, when properly connected, will satisfy a broad range of requirements of this type.

Mixing the outputs of several 106As, instead or purchasing a special purpose multi-pulse generator, offers many advantages. First, pulse parameters may be controlled individually; second, all pulses are selectable in polarity -- a feature not always available on multi-pulse generators; third, such an arrangement is more versatile since the individual units may be broken down for use on other projects; and fourth, the combination of simple, proven, easily operated 106As is more dependable than complex special gear.

The 106A's may be driven in parallel from an external source, if sync with outside phenomena is desired, or driven in tandem (see Figure 2-10) using the sync output of one generator to externally drive the next. The first generator may be driven from an external source in the tandem arrangement also. Because of the fast rise character of the pulses and narrow widths available, pulse repetition rates approaching 20 mc may be synthesized.

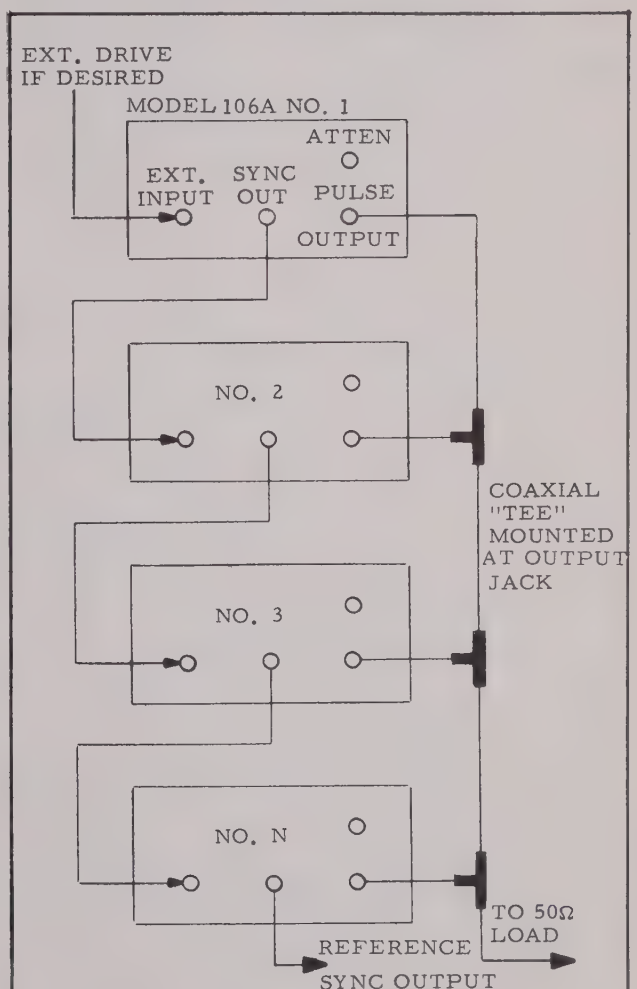
The termination of interconnecting cables has an important effect on output waveform in this arrangement. Improper termination causes reflections which deteriorate wave shape and increase the rise time. However, good waveform fidelity can be obtained, by inserting some measure of attenuation (the amount varying with the number of generators) at the generator end with the internal attenuator. The 50 ohm output impedance of the attenuator tends to terminate the interconnecting cables. The greatly decreased waveform distortion more than offsets the slight loss of amplitude sustained. (See Section 2.3.8)

2.4.2 Negative Sync Output

Some applications require negative polarity sync pulses which are not normally available in the Model 106A. DATAPULSE Model 2101 trigger pulse inverting transformer, available as an accessory, was designed to permit inversions of the positive sync pulse output.

2.4.3 Further Applications

For further applications and service information, refer to the Application & Service Bulletins in the rear of this manual.



NOTE: Sync occurs approximately 50 ns after external trigger. Reference sync will occur N x 50 ns after external trigger if N equals the number of generators.

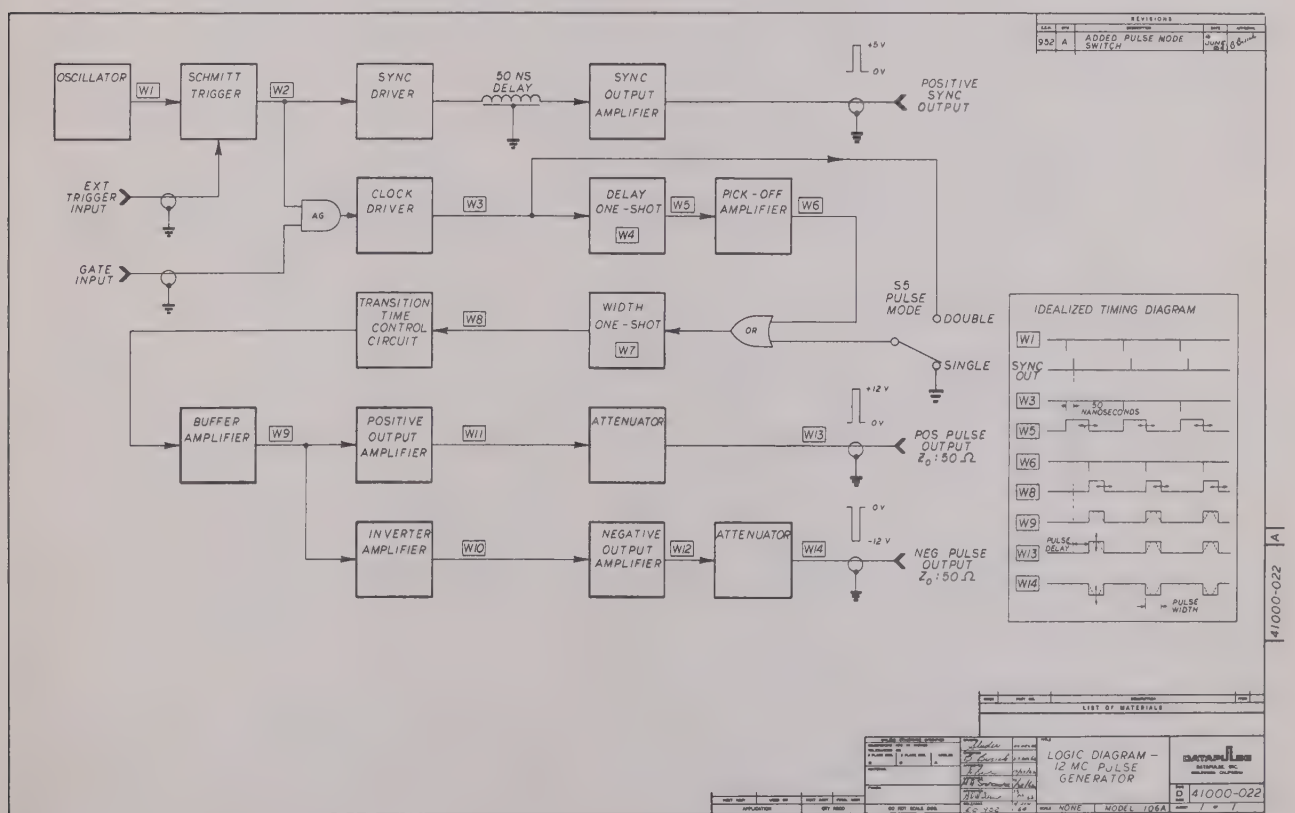
Figure 2-10. Wiring for Multiple Pulse Output.

SECTION III

THEORY OF OPERATION

3.1 BLOCK DIAGRAM DESCRIPTION

A pulse repetition rate (W1), variable between 10 cps and 10 mc, is developed by the internal oscillator. Either this signal (W1) or an external trigger input is applied to the Schmitt trigger circuit to provide a standardized trigger (W2). W2 is delayed 50 nanoseconds and becomes the positive sync pulse output which is used as a "Zero" time reference for the pulse delay circuit. W2 is also "Anded" with the external gating signal, if present, to produce the system clock (W3). The clock drives the delay one-shot multivibrator to produce a delay gate (W5). The lagging edge of the W5 is differentiated by a pickoff amplifier, yielding a delayed trigger W6 which drives the pulse width one-shot multivibrator. When the pulse mode switch is in the double pulse position, the system clock (W3) is "ORed" together with the delay one shot pick-off (W6) to trigger the width one-shot. In this mode, the width one-shot is triggered twice for each system clock. The width gate (W8) produced by the pulse width multivibrator is shaped into a variable rise and decay pulse by the transition time control circuit. This pulse is buffered and becomes an output driving pulse (W9). W9 is transformed into a current pulse (W11) by the positive output amplifier and is attenuated to the desired level by a constant impedance (50 ohm) attenuator to give the positive output pulse (W13). W9 is inverted to give W10 which drives the negative output amplifier where it is transformed into a current pulse (W12) which is attenuated to the desired level by a constant impedance (50 ohm) attenuator yielding the negative output pulse (W14).



3.2 CIRCUIT DESCRIPTIONS

3.2.1 Internal Oscillator

The internal oscillator is an emitter coupled RC oscillator which functions as follows:

Assume Q2 has just begun to conduct, its collector dips negative. This signal on the base of Q3 drives its emitter negative. The negative signal at the emitter of Q3 is coupled across C_t to the emitter of Q2 causing conduction to increase. The increase of conduction through Q2 causes its collector to dip more negative, regeneratively driving Q2 toward saturation until the clamp voltage of the anode of CR1 is reached. C_t charges through Q2, R6, and R10. As C_t becomes charged to the signal voltage, its contribution to the current through R6 will decrease. As the current through R6 decreases, the collector of Q2 moves positive. This positive going signal on the base of Q3 causes the emitter of Q3 to move positive and the positive going waveform is coupled across C_t to the emitter of Q2 decreasing conduction. As conduction of Q2 decreases its emitter becomes more positive regeneratively cutting off Q2. C_t now discharges through R_t and Q3. When C_t has discharged down to the level set at the base of Q2, Q2 will again begin to conduct and the cycle will be repeated. The negative spike at the collector of Q2 is emitter-follower coupled to the Schmitt trigger circuit by Q4. Q1 provides a low impedance clamp voltage for CR1.

3.2.2 Schmitt Trigger Circuit

The Schmitt circuit is used to standardize waveforms either from the internal oscillator or external triggers having varying wave shape. Because of regeneration during switching, the output of the Schmitt circuit has relatively constant rise time time regardless of input wave shape. The operation is as follows.

Initially, Q5 is conducting. The emitters of both Q5 and Q6 are at approximately the base potential of Q5. Q5 is set by the voltage divider and is composed of R40, R41, and R42. The collector of Q5 is clamped by CR40 to another point on the divider. The base of Q6 is set by the divider, consisting of R45 and R47, to a point more negative than its emitter and Q6 is cut off.

When a negative signal is applied to the base of Q5, the conduction of Q5 decreases and the collector potential rises. The positive going signal on the collector of Q5 is coupled to the base of Q6, causing Q6 to conduct and the emitter potential of Q6 (and thus, of Q1) to rise. This causes the conduction of Q5 to decrease further, the collector potential to rise, etc., and Q5 is regeneratively cut off.

Positive going inputs initiate "switching" at the base of Q6 and the rest of the cycle is similar to that for negative triggering.

Output of the circuit is taken from the collector of Q6.

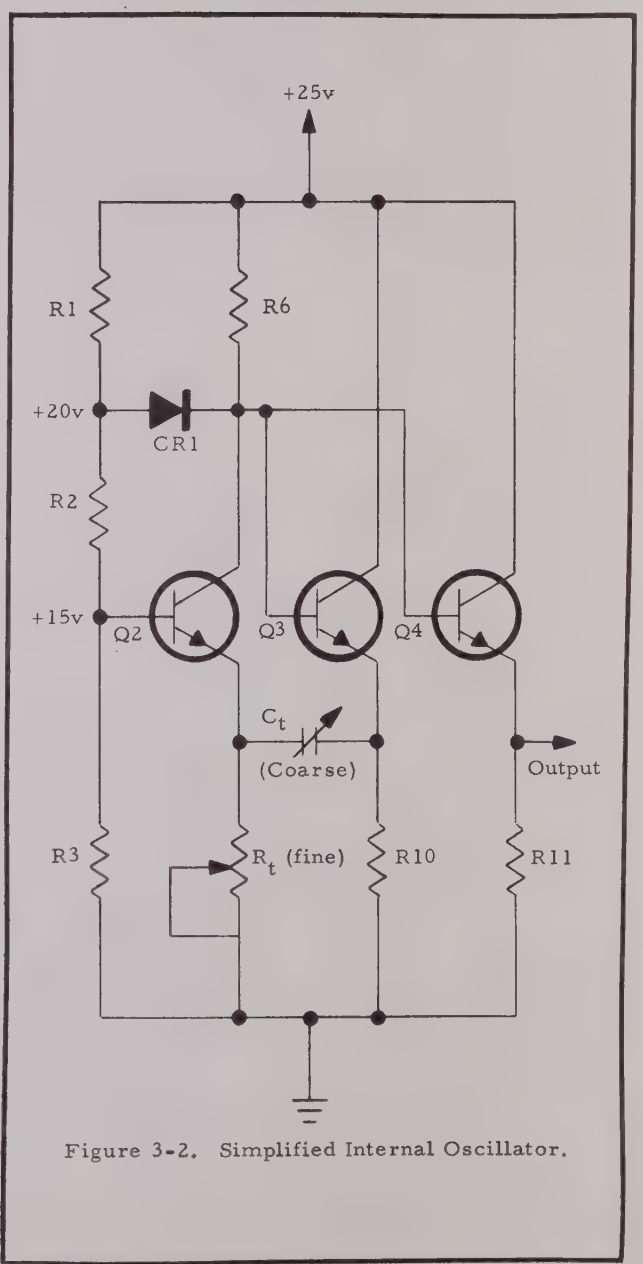


Figure 3-2. Simplified Internal Oscillator.

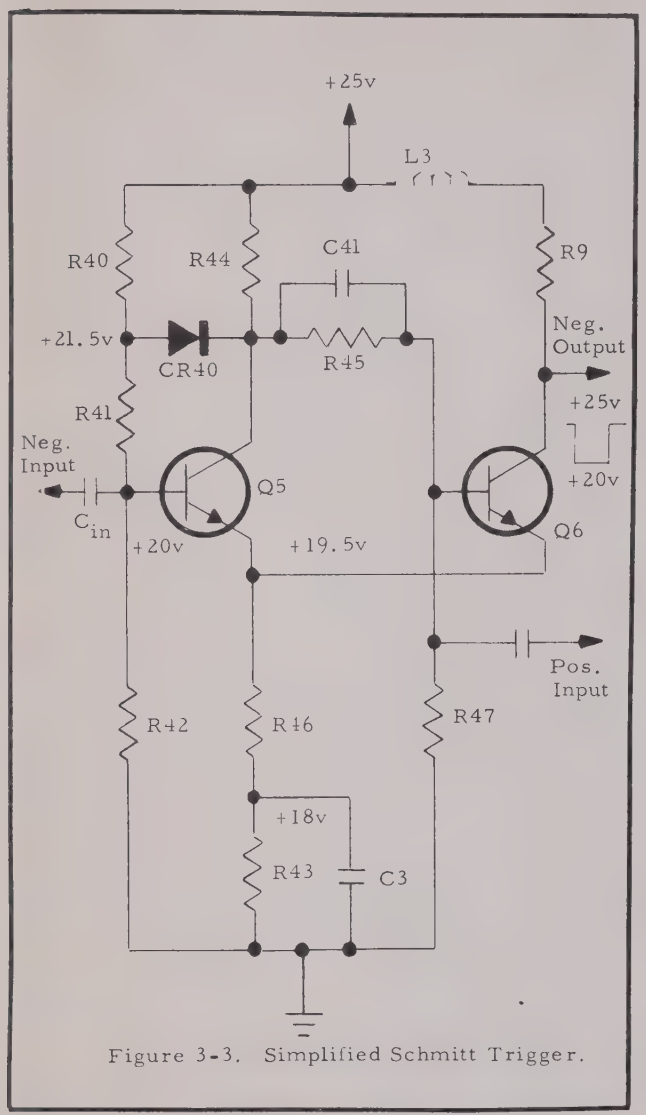


Figure 3-3. Simplified Schmitt Trigger.

3.2.3 One-Shot Multivibrator

The pulse delay circuitry is an emitter coupled one-shot multivibrator. As pulse width is essentially a delay function (i.e., the delay of trailing edge with respect to leading edge), the same technique is used to perform both operations. The circuit functions as follows:

In the static state Q13 is held on by the bias developed across CR73 and CR75. The collector of Q13 is clamped at approx. -4v by CR74. Upon the application of a negative trigger at the base of Q13, Q13 is turned off and its collector rises toward +25v, but is clamped at ground by CR76. This positive step is emitter-follower coupled to C_t by Q14, coupled across C_t and through emitter followers Q15 and Q16 back to the emitter of Q13. C_t now begins to charge through R_t, R76, and Q14. When C_t has changed to the signal voltage, Q13 again begins to conduct. The collector of Q13 drops back to the -4v clamp level and C_t discharges through R74, R76, and CR77.

Output is taken off of collector at Q13. This gate is delivered to the pickoff amplifier Q17 in the case of pulse delay. For pulse width the gate output from the collector of Q20 is emitter-follower coupled by Q24 to the output pre-amplifier.

3.2.4 Pickoff Amplifier

The pickoff amplifier uses a non-inverting transformer (T110) to differentiate the gate produced by the delay one-shot multivibrator. Its operation is as follows.

Initially, steady state current flows in Q17 and the primary of T110. The base of Q18 is biased at -5v. As Q18 is an emitter follower, its emitter is at approximately -5v and holds Q19 cutoff. The collector of Q19 is clamped at ground by CR110.

At the initiation of the delay gate, the base of Q18 is driven positive increasing conduction. This causes the collector to dip negative as a magnetic field is built up in T110. The negative going signal is applied to the base of Q18 and then to the base of Q19. As Q19 is already cut off no change takes place in its collector circuit. The magnetic field in T110 is soon built up and negative pulse subsides.

At the termination of the delay gate, the negative going trailing edge causes current in Q17 to decrease and the field in T110 collapses causing a positive spike at the base of Q18. This positive spike is coupled to the base of Q19. Q19 then conducts driving its collector sharply negative, producing a negative delayed trigger.

3.2.5 Transition Time Control Circuit

Transition time control is accomplished through controlled charge and discharge of known values of circuit capacity.

Consider the circuit shown in Figure 3-6. There are two sets of paraphase amplifiers, namely, Q26, Q28 and Q27, Q29. In the set, Q26, Q28, the base of Q26 is biased more negative than +5v by the drop across CR201, while the base of Q28 is biased more positive than +5v by the drop across CR202 and CR203. This difference is sufficient to cause Q26 to conduct and Q28 to be cut off. In the set composed of Q27 and Q29, the base of Q27 is biased more negative than -5v by the drop across CR209, while the base of Q29 is held at -5v. This biasing is such that Q27 is cut off and Q29 is conducting. The collector of Q29 is clamped at ground by CR204.

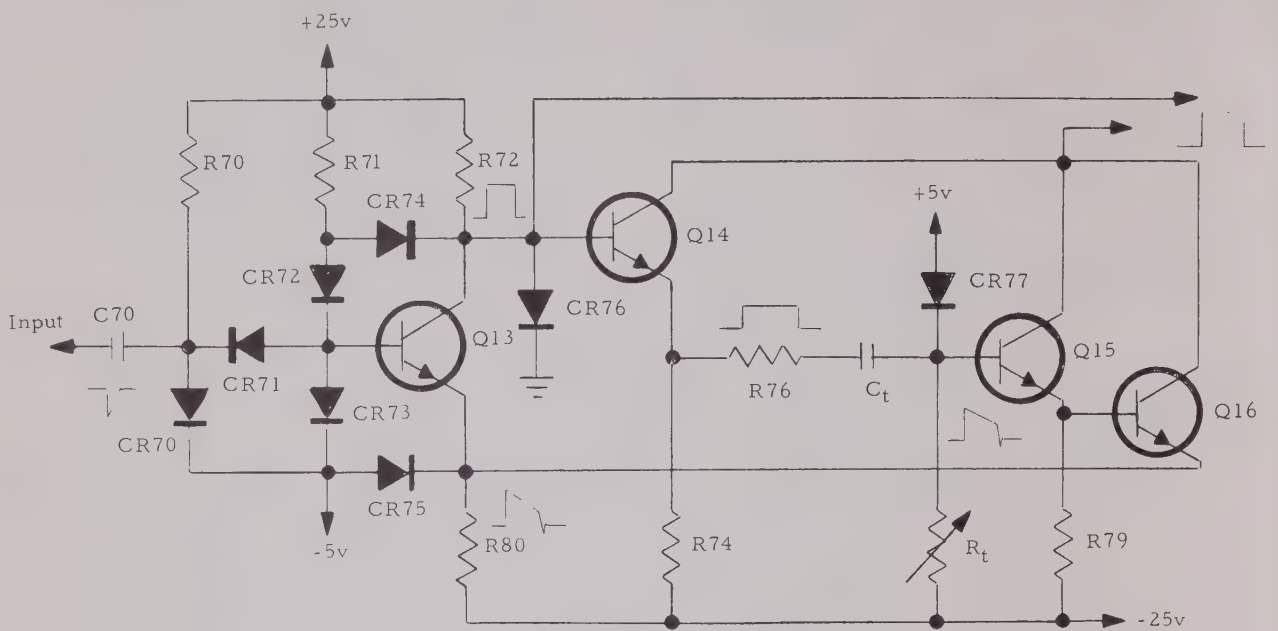


Figure 3-4. Simplified One-Shot Multivibrator.

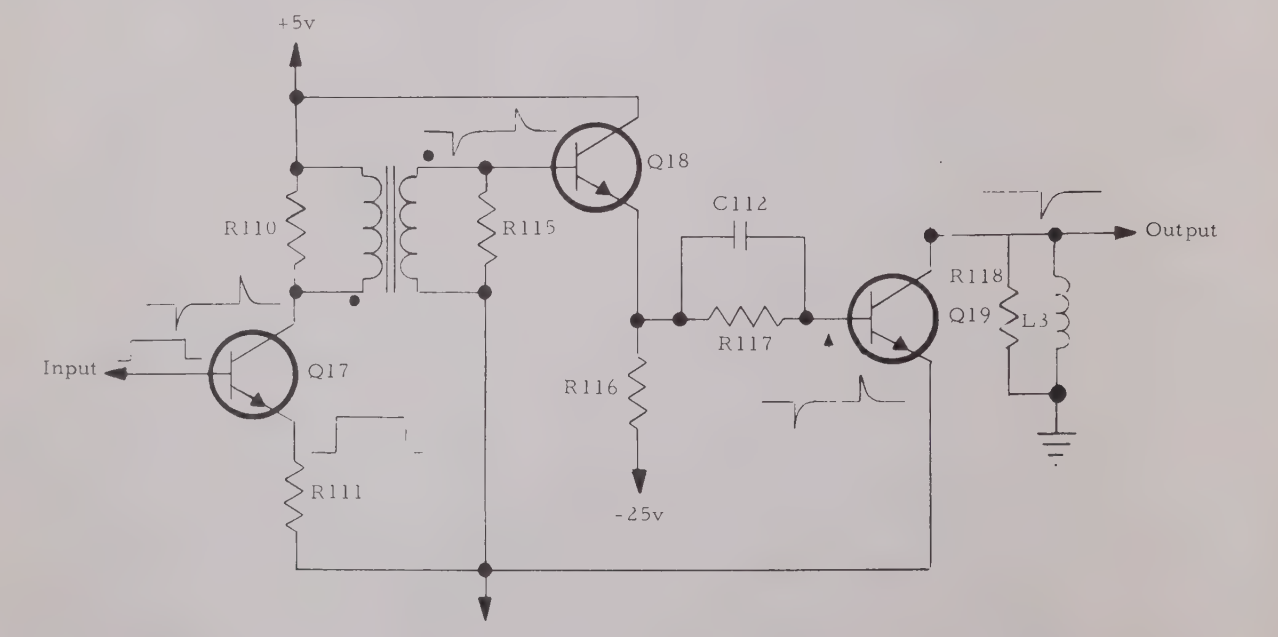


Figure 3-5. Pickoff Amplifier

The positive pulse width gate is applied simultaneously to the base of Q26 and Q27 causing Q26 to turn off and Q27 to turn on. As Q26 turns off Q28 comes on and as Q27 comes on Q29 turns off. With Q28 on, C_t begins to charge through Q28 and R_{le}. The current through Q28 is constant and determined by R_{le}* causing C_t to charge in a linear manner rather than the usual exponential curve. When C_t has charged to the voltage +v, the top of the pulse is clamped by CR205 and CR206. At the end of pulse time, the positive pulse width gate subsides. Q27 and Q28 are once again turned off and Q26 and Q29 begin to conduct. C_t now discharges through Q29 and R_{te}*, causing C_t to discharge in a linear manner. When the output reaches ground, it is clamped by CR204 and the circuit has returned to its static state.

The output is applied to the buffer emitter followers Q31 and Q32 and then to the output units. The voltage +v is determined by R215 through emitter follower Q30. R215 is used as a positive amplitude adjust.

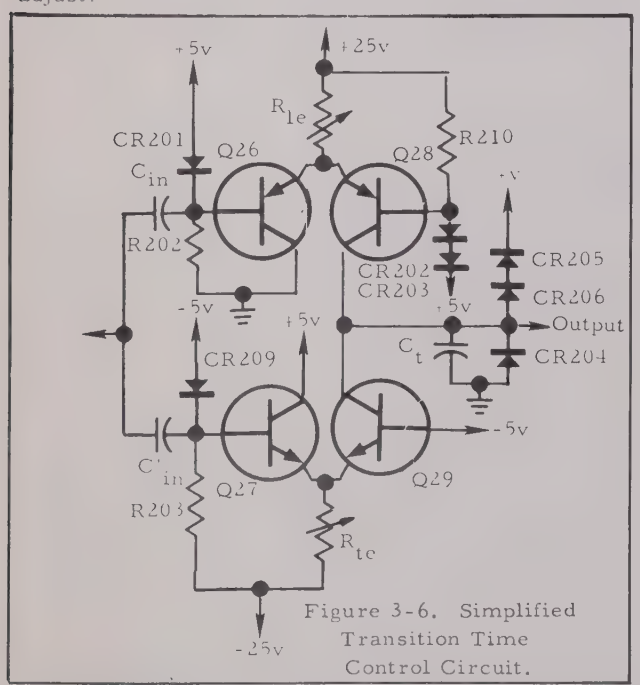


Figure 3-6. Simplified Transition Time Control Circuit.

* The emitter current of a transistor with resistance in the emitter circuit is approximately: $\frac{E\ signal}{R\ emitter}$ or in the case of Q29; $I_e = \frac{25-5}{R_{te}} \approx \frac{20}{R_{te}}$; collector current is alpha times emitter current. As alpha is very nearly one $I_c \approx I_e$ and is constant. The same case is true for Q28 by replacing R_{te} with R_{le}.

3.2.6 Output Stages

The output stages consist of current drivers working into a 50 ohm load. Constant current output has the advantage of built-in short circuit protection in that it is relatively insensitive to load impedance. (i.e no more current flows in a shorted output than when not shorted.) The total circuit for each polarity consists of five current drivers operating in parallel giving a total of 200 milliamperes. Each section operates as follows.

In the static state, the base of Q1 is more negative than $+V_b$ by the drop across CR1 and its emitter more negative still by the base-emitter drop. This places the emitter of Q2 more negative than its base and holds Q2 cutoff.

Upon the application of a positive going signal to the base of Q1, the base-emitter diode of Q2 is forward biased, and current of a magnitude $\frac{E\ signal}{R\ emitter}$ flows in the emitter of Q2. A current of approximately this magnitude* flows in the collector of Q2 and consequently into the load R_L. As the positive pulse input subsides, the circuit reverts to the static state.

The negative pulse output circuit operates in the same manner, however, voltage polarities are reversed and Q1 is PNP, Q2 NPN.

The output current of 200 milliamperes provides 10v when delivered into 50 ohms. A constant impedance attenuator is used to provide voltage outputs of less than 10v.

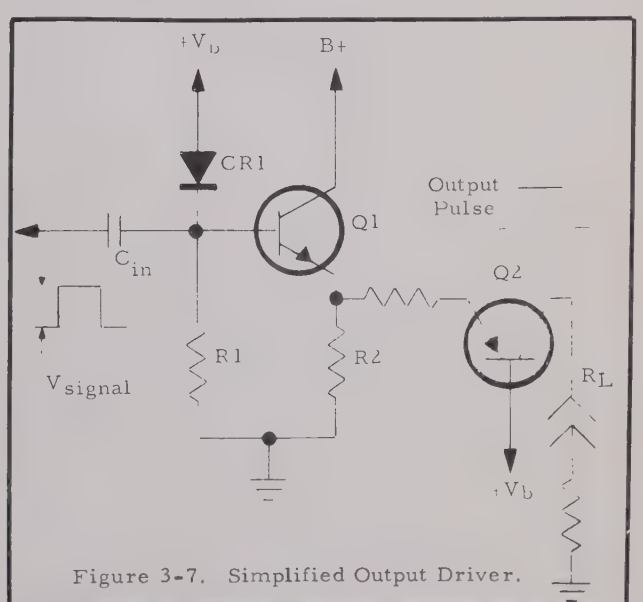


Figure 3-7. Simplified Output Driver.

* Alpha times emitter current flows in the collector circuit. As alpha is on the order of 0.95 to 0.98, this is nearly the same current that flows in the emitter circuit.

SECTION IV

MAINTENANCE INSTRUCTIONS

4.1 PREVENTIVE MAINTENANCE

4.1.1 Preventive Inspection and Service

Inspection and service of a preventive nature will result in optimum performance and longer life of this instrument. Dust covers should be removed at regularly scheduled intervals to permit inspection for dust, tarnish, corrosion, loose nuts and bolts (especially those serving as electrical conductors), loose cables and fuses, charred insulation, scorched resistors and broken wiring. Discoloration of the printed circuit board, due to heat, does not affect the board's electrical properties and may be disregarded in most cases.

4.1.2 Minor Repairs

The operator should be thoroughly acquainted with the instrument's circuit theory and component location before attempting repair. In all cases, setting and adjustment of controls should be checked in order to verify that difficulties encountered are actually caused by malfunction and not by operation outside of specifications. Check transistors in suspected circuits prior to conducting extensive tests on other components. A check of the important waveforms as shown on schematics will be of great assistance.

4.1.3 Recalibration

This instrument was designed to provide maximum reliability and stability. To insure that accuracy remains within stated limits, we suggest that calibration be checked after every 200 hours of operation. See Section 4.5 for calibration check. If the unit is used intermittently, calibration should be checked every three months. Complete instructions for calibration are given in this manual.

4.2 PARTS REMOVAL AND REPLACEMENT

4.2.1 General

This instrument is sturdily built and easily accessible. Removal of most parts is so simple that explanations are unnecessary. However, some parts are more easily removed if a definite procedure is followed. Replacement of some parts will also require partial recalibration. Refer to Section 4.4 of this manual for calibration instructions.

4.2.2 Removal of Dust Covers

The dust covers are held in place by small screw-head fasteners. To remove, turn the fasteners a quarter turn counterclockwise with a common screwdriver. To remove the top dust cover: (1) loosen the four fasteners in the sides of the bottom dust cover; (2) remove the four fasteners on the sides of the top dust cover; (3) loosen the two fasteners on the top of the dust cover; and (4) lift the cover up and off.

To remove the bottom dust cover: (1) turn the instrument upside down; (2) remove the four fasteners on the sides of the bottom cover; (3) loosen the four fasteners on the bottom of the cover; and (4) lift the cover up and off.

4.2.3 Replacement of Power Transistors

The power transistors which are mounted to the rear panel must have a thin film of silicon grease (such as Dow-Corning DC-4) applied to their common contact surfaces.

4.2.4 Soldering Considerations

Although printed wiring is quite vulnerable to heat excesses, a great deal of resoldering can be done on a single joint if care is taken. A 35-watt wedge tip or pointed tip iron and 60-40 rosin core solder are quite effective. Where both sides of the board are accessible apply the tip of the iron (on the side opposite the component) directly to the solder fillet and pull gently on the pigtail with pliers from the opposite side. Where both sides of the circuit board are not accessible, the component lead will be fed through the board through an eyelet. Apply the iron tip to the eyelet and pull the pigtail out with the pliers. To insert a new component, clean out the hole with a sharp object (it may be necessary to apply more heat) and insert the new component, soldering in the old place.

4.3 TROUBLESHOOTING PROCEDURE

Before any troubleshooting is attempted the front panel controls should be checked for proper setting. You may wish to refer to paragraph 3.2, "Operating Considerations" which details many of the limitations of the instrument and describes the performance to be expected. After you have ascertained that a trouble does exist, you may continue according to the procedures outlined in this section.

Many apparent malfunctions are due to improper calibration of one or more of the circuits, and often a transistor is replaced that requires recalibration. If you suspect that a circuit is miscalibrated refer to Section 4.5 of this manual, which describes a procedure for determinig calibration status. Section 4.4 provides a detailed calibration procedure.

Whenever trouble occurs check the power supply voltages. This test may be done by following paragraph 4.4.3 of the "Calibration Procedure". It may be assumed that the power supplies are functioning properly if the output and ripple voltages are correct.

When malfunction can be attributed to a particular circuit, perform a complete visual inspection in that area. See Figure 4-1 for the location of circuits. Frequently visual inspection reveals the effects of the trouble (such as burned resistors) rather than the cause. However, these effects may give clues as to the actual cause. Care should be taken to find the real cause.

TABLE 4-1. VOLTAGE AND RESISTANCE

(Refer to Notes at rear of Table for explanation of conditions under which measurements were made.)

TRANSISTOR	CIRCUIT	VOLTAGE			RESISTANCE					
		Emitter	Base	Collector	Emitter		Base		Collector	
Q1	Oscillator	+19.5	+19.5	+13.5	*270	*550	*530	*320	*270	1k
Q2	Oscillator	+14.5	+15	+25		3k	*550	*550	*450	*460
Q3	Oscillator	+24	+24.7	+25	1.6k	1.6k	*440	*460	*120	*150
Q4	Oscillator	+24	+24.7	+25	2.9k	2.5k	1k	*500	*150	*120
Q5	Schmitt Trigger	+16.8	+17.6	+19.5	1.5k	1.6k	1k	1.1k	*600	*500
Q6	Schmitt Trigger	+16.8	+16.7	+24.8	1.7k	1.5k	1.6k	2.7k	*470	*600
Q7	Clock Driver	+24	+24.8	+25	*950	*500	*430	*650	*120	*150
Q8	Clock Driver	+.5	+.25	-5	1k	1k	*170	*550	*250	*330
Q9	Clock Driver	+.5	+.2	-5	1.3k	3.2k	4.8k	1.2k	*250	1k
Q10	Sync Pulse Forming	+.7	+.5	-5	*350	*800	*350	*500	*250	*330
Q11	Sync Pulse Forming	-.06	+.7	0	4.2k	1.9k	*250	*550	* 0	* 0
Q12	Sync Pulse Output	-.6	-.06	-6.8	1.8k	1.7k	4.2k	1.9k	1.2k	1.2k
Q13	Delay One-Shot	-6	-5	-4.8	2k	2.1k	1.5k	25k	*100	2.8k
Q14	Delay One-Shot	-5.6	-4.9	+5	3.5k	2.8k	*210	2.9k	*25	*90
Q15	Delay One-Shot	-6.2	-5.5	+5	2.4k	8.5k	2.3k	4k	*25	*90
Q16	Delay One-Shot	-5.8	-6.2	+5	2k	2.1k	2.4k	8.5k	*25	*90
Q17	Pickoff Amplifier	-5	-4.8	+5	2k	1.3k	*130	2.8k	*25	*90
Q18	Pickoff Amplifier	-5.6	-5	+5	2.7k	3.4k	*260	*370	*25	*90
Q19	Pickoff Amplifier	-5	-5.6	-.36	*250	*330	2.7k	4k	*110	2.6k
Q20	Width One-Shot	-5.7	-5	-4.8	2k	2.1k	1.6k	25k	*100	3k
Q21	Width One-Shot	-5.4	-4.8	+5	3.7k	2.7k	*220	3k	*25	*90
Q22	Width One-Shot	-6.2	-5.5	+5	2.4k	7.5k	2.4k	3.9k	*25	*90
Q23	Width One-Shot	-5.7	-6.2	+5	2k	2.1k	2.4k	7.5k	*25	*90
Q24	Width Gate Output	-5.5	-4.8	+5	3.3k	2.8k	*220	3.1k	*25	*90
Q26	TR Time Constant	+4.7	+4.5	0	1.4k	11k	10k	*100	0	0
Q27	TR Time Constant	-5.7	-5.6	+5	15k	3.5k	2.4k	4k	*25	*90
Q28	TR Time Constant	+4.7	+6	-.6	1.4k	11k	8k	3.3k	2.6k	2.1k
Q29	TR Time Constant	-5.7	-5	-.6	15k	3.5k	*330	*400	2.6k	2.1k
Q30	TR Time Constant	+3.5	+4.3	+4.6	*120	*120	*260	*330	*35	*100
Q31	Buffer	-1	-.55	+3.5	2.4k	3k	2.5k	2.3k	*120	*120
Q32	Buffer	-1.7	-1	+5	2.1k	3.5k	2.2k	3.4k	*25	*90
Q33	Pos. Input	-2.4	-1.7	+5	3.5k	3.5k	2.1k	3.5k	*25	*90

* x 100 range

CONTINUED

TABLE 4-1. VOLTAGE AND RESISTANCE --continued

(Refer to Notes at rear of Table for explanation of conditions under which measurements were made.)

TRANSISTOR	CIRCUIT	VOLTAGE			RESISTANCE					
		Emitter	Base	Collector	Emitter		Base		Collector	
Q34	Inverter	-5	-4.8	+11.5	*500	1.3k	3.4k	3.5k	1.5k	1.5k
Q35	Neg. Input	+10.6	+11.4	+11.5	*900	*750	1.6k	1.6k	1.2k	1.2k
Q36	Pos. Output	+12.5	+13	+20.5	*460	*850	3.9k	3.3k		2.8k
Q37	Pos. Output	+12	+12.5	+20.5	*190	1.9k	*490	*850		2.8k
Q38	Pos. Output	+12	+12.5	+20.5	*200	1.9k	*500	*850		2.8k
Q39	Pos. Output	+12	+12.5	+20.5	*200	1.8k	*500	*850		2.8k
Q40	Pos. Output	+12	+12.5	+20.5	*190	1.8k	*500	*900		2.8k
Q41	Pos. Output	+12	+12.5	+20.5	*190	1.9k	*500	*900		2.8k
Q42	Pos. Output	+12	+11.8	+.12	*110	2k	*100	*130	*50	*50
Q43	Pos. Output	+12	+11.8	+.12	*120	2k	*100	*130	*50	*50
Q44	Pos. Output	+12	+11.8	+.12	*130	1.9k	*100	*130	*50	*50
Q45	Pos. Output	+12	+11.8	+.12	*110	1.9k	*100	*130	*50	*50
Q46	Pos. Output	+12	+11.8	+.12	*120	2k	*100	*130	*50	*50
Q47	Pos. Output Bias	+11.8	+11.6	+5	*100	*130	1.2k	*1.8k	*25	*90
Q48	Neg. Output	-10.5	-10.6	-21	*550	*300	1k	1.4k	*520	200k
Q49	Neg. Output	-10.2	-10.5	-21	*500	1.9k	*580	*340	*520	200k
Q50	Neg. Output	-10.2	-10.5	-21	*500	1.9k	*600	*340	*520	200k
Q51	Neg. Output	-10.2	-10.2	-21	*550	*300	*560	*310	*520	200k
Q52	Neg. Output	-10.2	-10.5	-21	*500	1.9k	*590	*340	*520	200k
Q53	Neg. Output	-10.2	-10.5	-21	*500	1.9k	*600	*340	*520	200k
Q54	Neg. Output	-10.2	-9.5	-.1	*580	2k	1.5k	2.4k	*50	*50
Q55	Neg. Output	-10.2	-9.5	-.1	*580	2k	1.5k	2.4k	*50	*50
Q56	Neg. Output	-10.2	-9.5	-.1	*650	*320	1.5k	2.4k	*50	*50
Q57	Neg. Output	-10.2	-9.5	-.1	*580	2k	1.5k	2.4k	*50	*50
Q58	Neg. Output	-10.2	-9.5	-.1	*580	2k	1.5k	2.4k	*50	*50
Q59	Neg. Output Bias	-9.5	-8.8	-6.7	1.5k	2.4k	3k	2.3k	*700	*800
Q501	+25v Supply	+9.3	+9.1	.45	*440	3.4k	*750	*630	*440	3.4k
Q502	+25v Supply	-.22	+.45	+5	*85	*40	*440	3.4k	*25	*90
Q503	+25v Supply	0	-.22	-21	0	0	*90	*45	*50	*90
Q504	+12v Supply	+8.4	+9	+13	1.3K	1.3K	*600	*850	*370	*400
Q505	+5v Supply	+3.5	+4.05	+8.5	*570	*40	*480	*700	1.3k	1.3k
Q506	+5v Supply	+3.5	+3.5	0	*25	*90	*570	*40	0	0

* x 100 range

CONTINUED

TABLE 4-1. VOLTAGE AND RESISTANCE -- continued

TRANSISTOR	CIRCUIT	VOLTAGE			RESISTANCE					
		Emitter	Base	Collector	Emitter		Base		Collector	
Q508	-25v Supply	-25	-25.5	-38	*360	*440	1.6k	*520	*550	*480
Q509	-25v Supply	-25.5	-24.5	-22.5	1.6k	*540	1.6k	11k	*360	*460
Q510	-25v Supply	-30	-30.2	-24.5	2.6k	6k	*1k	*1k	1.6k	11k
Q511	-5v Supply	-4.3	-4.5	-12.5	*260	*600	*600	*300	*260	*850
Q512	-5v Supply	-5	-4.3	-1.4	*280	*330	*260	*580	*20	*20
Q513	-7v Supply	-6.7	-6	-1.5	*730	*820	2.9k	11k	*20	*20

* x 100 Range

MEASUREMENTS WERE MADE UNDER THE FOLLOWING CONDITIONS

All switches in position shown on schematic, vernier fully clockwise.

All measurements were made with respect to ground.

All measurements were made with Triplett Model 630 Multimeter (20,000 ohms-per-volt). Note: Some meters have different internal wiring on resistance ranges. In this case, polarity of resistance readings may be reversed.

Resistance readings in second column indicate positive meter lead connected to ground.

The x1k resistance range was used unless noted. Use of higher ranges employ voltages that may be injurious to transistors. The voltages and resistances tabulated here are typical values. On some instruments the readings may differ considerably from this tabulation due to manufacturing tolerances and variations in component characteristics. This table should be used in conjunction with careful study of the schematic diagrams and the "Theory of Operation" section of this manual.

All voltages are dc.

All voltage measurements were made with 115v ac line voltage.

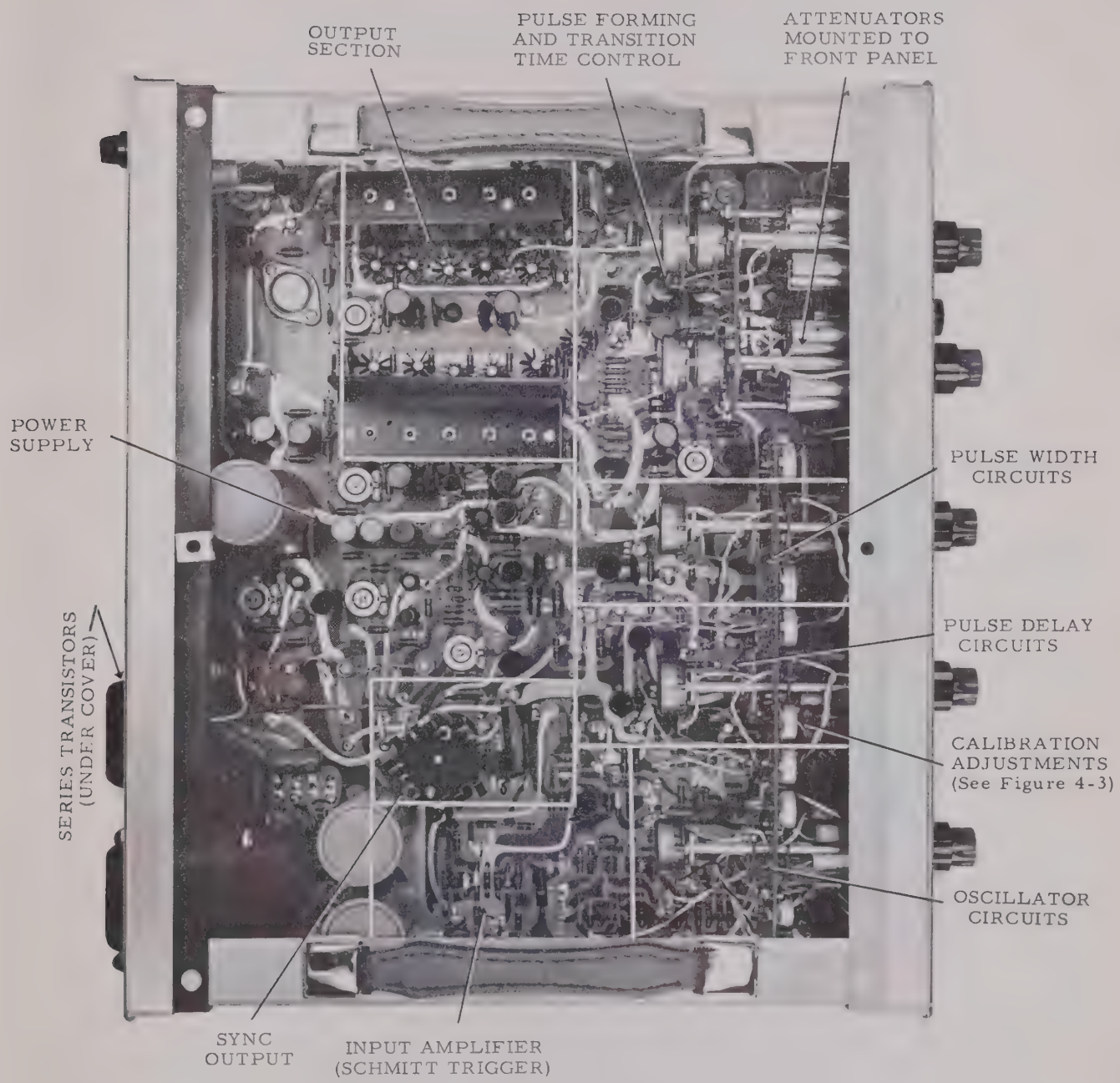


Figure 4-1. Circuit Locations

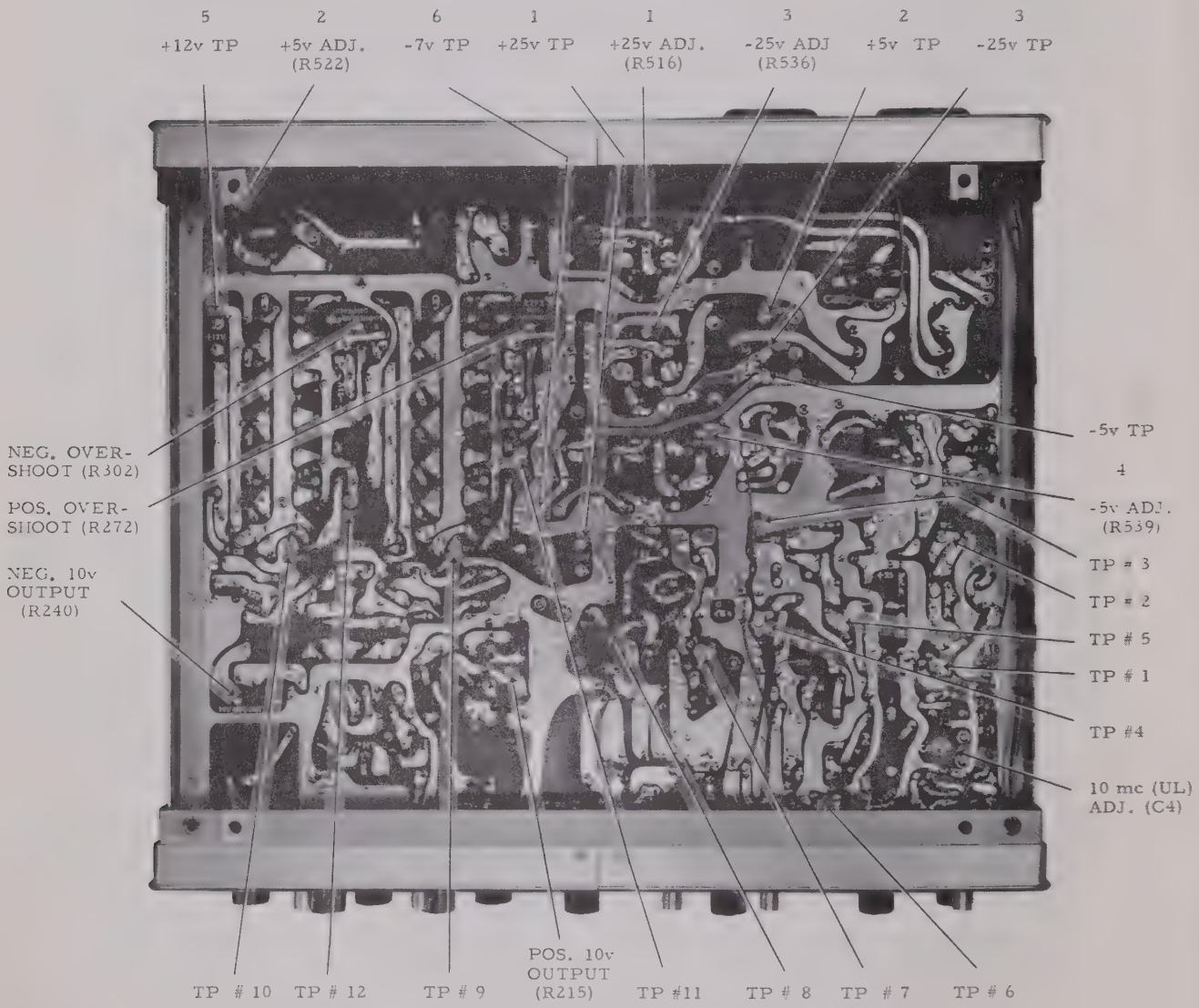


Figure 4-2. Adjustment and Test Point Locations

4.3.1 Troubleshooting the Power Supplies

Almost all power supply failure may be typified by collector to emitter shorts (transistors) and anode to cathode shorts (rectifiers and zener diodes). These conditions are easily detected "in circuit" with an ohmmeter because they measure zero resistance in both directions.

4.3.2 Troubleshooting the Pulse Circuits

Once it has been ascertained that the power supplies are functioning correctly, the most straight forward method of tracking down a trouble is to begin at test point #1 and proceed through the instrument comparing waveforms to those listed in the schematic. When the proper waveform is distorted or missing entirely, then a comparison of voltage and resistance readings to those listed in Table 4-1. will generally narrow the trouble down to one of a very few components. Because of the "straight through" nature of the instrument circuitry, most troubles will manifest themselves as complete absence of output pulses or invariability of one or more of the pulse parameters. In the later case a good indication is given as to which circuit to suspect.

4.4 CALIBRATION PROCEDURE

4.4.1 General

Remove dust covers and connect instrument and ac voltmeter to auto transformer. Set to 115v ac (230v if so wired) and energize instrument. Allow five minutes warmup before commencing calibration. During this period make sure that the instrument is working properly. If any portion of the instrument fails to calibrate, repair should be effected before attempting to complete calibration.

4.4.2 Equipment Required

a) RMS reading ac voltmeter with 0-150v range (0-300v range if wired for 230v operation).

b) Variable line auto transformer such as Powerstat Series 20.

c) A multimeter with an accuracy of at least 3% and a sensitivity of 20,000 ohms per volt. Triplett 630 or equivalent.

d) A general purpose oscilloscope of at least 30 mc band-pass with either delayed sweep or high sweep magnification. Hewlett-Packard 175A or Tektronix 543 is adequate.

e) A wide band oscilloscope such as HP Model 185B is necessary for fine adjustment of output waveform.

f) 50 ohm, 5%, 15w termination. (DP#2002A)

g) An insulated, low-capacity screw driver.

h) Optional: 10 mc counter HP MODEL 5243 or equivalent.

4.4.3 Power Supply Calibration

As the timing circuits are dependent upon the regulated power supply voltages for reference, any variances of these voltages will necessarily cause a change in calibration accuracy. Therefore, these adjustments should not be attempted unless one is prepared to carry out complete recalibration.

Due to internal referencing within the power supply the following sequence of adjustment must be followed:

a) Connect a dc voltmeter from +25v test point to ground. Set R516 (+25v adj.) for a reading of 25v. Vary line voltage ±10% around 115v and verify regulation.

b) Connect dc voltmeter from +5v test point to ground. Set R522 (+5v adj.) for a reading of 5 volts.

c) Connect dc voltmeter from -25v test point to ground. Set R536 (-25v adj.) for a reading of 25 volts. Vary line voltage +10% around 115v and verify regulation.

d) Connect dc voltmeter from -5v test point to ground. Set R539 (-5v adj.) for a reading of 5 volts.

e) Connect dc voltmeter from +12v test point to ground. Meter should read between +10v and +14v.

f) Connect dc voltmeter from -7v test point to ground. Meter should read between -6v and -8v.

g) Check ripple on all supplies. Ripple should be less than 30 mv peak-to-peak.

4.4.4 Repetition Rate Calibration

NOTE: As calibration accuracy of most oscilloscopes is in the range of ±5%, the ultimate calibration accuracy of the instrument is limited by this value, i.e., if the instrument is calibrated using an oscilloscope which is 5% off in one direction and is then checked with another which is 5% off in the opposite direction, a 10% deviation will be shown. If calibration is performed using a frequency meter type of counter such as HP Model 5243, driving the counter with the positive sync pulse output, calibration accuracies of 1% or better can usually be obtained. However, one must bear in mind that if the output is then viewed on a 5% oscilloscope this accuracy may appear as 6%. The following procedure is given for calibration of repetition rate using a counter.

a) Set DELAY and WIDTH controls to 0.05 μs with VERNIER fully counterclockwise.

b) Adjust oscillator according to Table 4-2. The deviation on the lower limit (LL) adjustment is to provide a small measure of overlap of ranges and assure continuous coverage of all frequencies. The reason for adjusting upper limit (UL) first is that the upper limit adjustment affects both ends of the range while the upper limit is independent of lower limit setting. When using oscilloscope for calibration, view the positive pulse output terminated into 50 ohms with a 10 ns rise time. Widen pulse as necessary for oscilloscope presentation.

TABLE 4-2
REPETITION RATE ADJUSTMENT

Rep. Rate Range	Vernier Position (R36)	Adj. To Be Made	Counter Reading	Pulse Spacing for Scope Calibration
0.1kc	cw	0.1kc UL(R32)	100cps	10ms
0.1kc	ccw	LL(R28)	10cps	0.1sec.
1kc	cw	1kc UL(R31)	1kc	1ms
1kc	ccw	LL(R28)	< 100 cps	10.0ms
10kc	cw	10kc UL(R30)	10kc	0.1ms
10kc	ccw	LL(R28)	< 1.0 kc	1.0ms
0.1mc	cw	0.1mc UL(R29)	100kc	10μs
0.1mc	ccw	LL(R28)	< 10 kc	100μs
1mc	cw	1mc UL(R27)	1mc	1μs
1mc	ccw	1mc LL(R28)	< 100 kc	10.0μs
12mc	cw	C4 (12mcUL	12mc	.0835μs
12mc	ccw	12mc LL(R26)	1.0mc	1.0μs

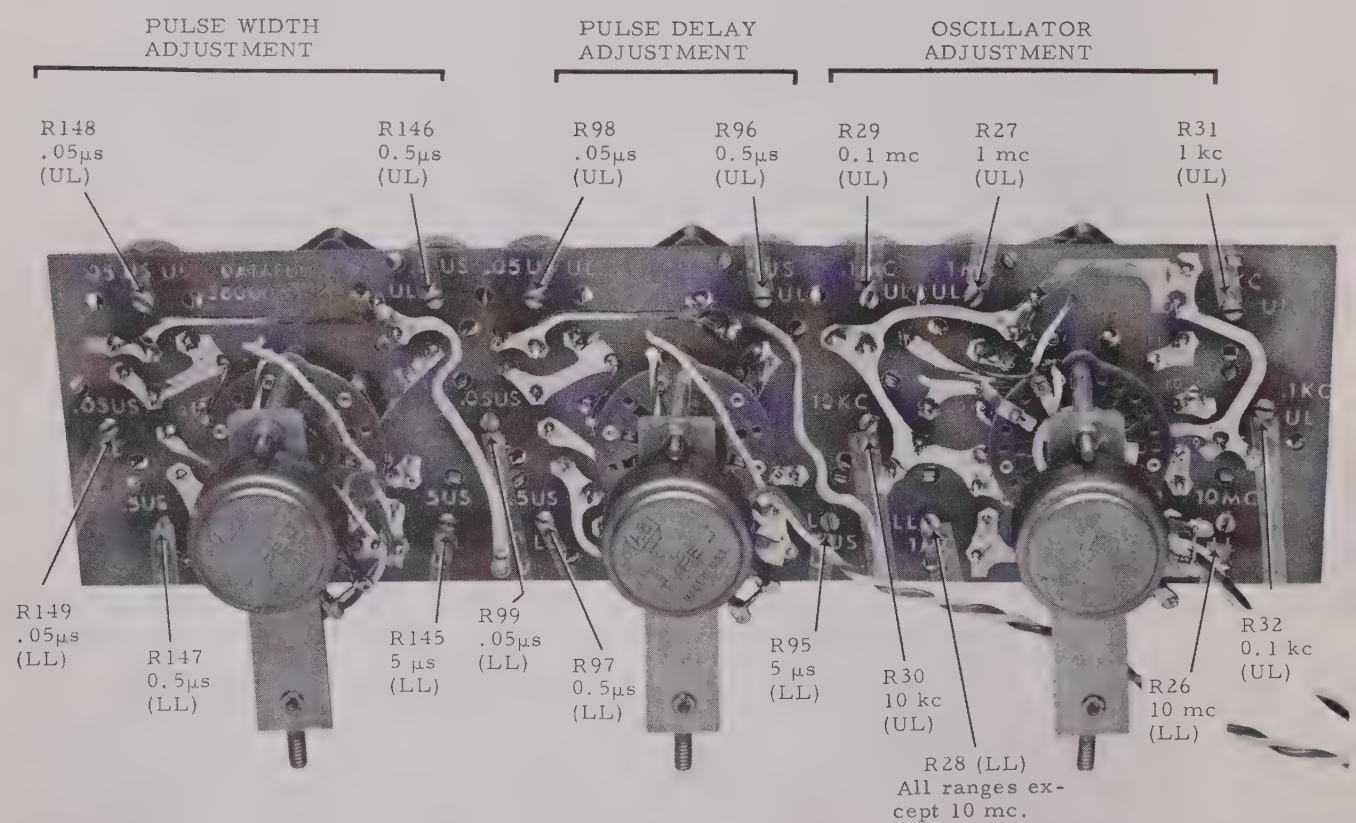


Figure 4-3. Calibration Adjustments

c) Recheck oscillator according to Table 4-3. It may be necessary to compromise setting of R28 (lower limit) so that the lower limit at the 1 mc through 0.1 kc ranges is within specification (i.e., less than the stated values).

TABLE 4-3
CHECK OF REPETITION RATE ADJUSTMENTS

Rep Rate Range	Vernier Position (R36)	Counter Reading ≥ =+5% -0%	Pulse Spacing for Scope Calibration
0.1kc	cw	≥ 100cps	10ms
0.1kc	ccw	< 10cps	0.1sec
1kc	cw	≥ 1kc	1ms
1kc	ccw	< 100cps	10. ms
10kc	cw	≥ 10kc	0.1ms
10kc	ccw	< 1kc	1ms
0.1mc	cw	≥ 100kc	10μs
0.1mc	ccw	< 10kc	100μs
1mc	cw	≥ 1mc	1μs
1mc	ccw	< 100kc	10μs
12mc	cw	≥ 12mc	0.835μs
12mc	ccw	< 1mc	1.0μs

4.4.5 Pulse Delay Calibration

Delay is measured from the 50% point on the leading edge of the positive sync output pulse to the 50% point on the main pulse output. Pulse delay accuracy is defined for output pulse rise time of 10 ns.

NOTE: For calibration of pulse delay, a dual trace oscilloscope is convenient but not mandatory. To use a single channel oscilloscope, first view the positive sync output and align the 50% point of the leading edge with the left hand edge of the graticule by using the horizontial position control. Next, view the main pulse output and make delay measurement using the left hand edge of the graticule as a reference. For dual trace oscilloscope, view sync on one trace and the output pulse on the other.

a) Pulse spacing $\frac{1}{\text{repetition rate}}$ must be kept at least ten times the delay setting. Set PULSE WIDTH to 0.5 μs,

b) Adjust delay according to Table 4-4: the long upper limit calibration points are to insure overlap at ranges giving continuous coverage.

TABLE 4-4
DELAY CALIBRATION ADJUSTMENT

Delay Range	Vernier Position (R100)	Adjustment	Set Delay for	Scope Sweep Speed (per cm)	Rep. Rate
0.05μs	ccw	0.05μs LL(R99)	50ns	50ns	0.1mc
0.05μs	cw	0.05μs UL(R98)	0.52μs	0.1μs	0.1mc
0.5μs	ccw	0.5μs LL(R97)	0.5μs	0.1μs	10kc
0.5μs	cw	0.5μs UL(R96)	5.2μs	0.5μs	10kc
5μs	ccw	5μs LL(R95)	5μs	0.5μs	1kc

c) Recheck delay calibration according to Table 4-5. It may be necessary to compromise the adjustment of R95 (5μsLL) such that the lower limit of the 0.05 ms and 0.5 ms ranges is within specifications. It may be necessary to compromise the adjustment of R96 (0.5 μs UL) such that the upper limit of 5 μs, 0.05 ms and 0.5 ms ranges is within specifications.

TABLE 4-5
CHECK OF DELAY CALIBRATION ADJUSTMENTS

Delay Range	Vernier Position (R100)	Delay ≷ =+0% -5%	Scope Sweep Speed (per cm)	Rep. Rate
0.05μs	ccw	~ 50ns	50ns	0.1mc
0.05μs	cw	> 0.5μs	0.1μs	0.1mc
0.5μs	ccw	≲ 0.5μs	0.1μs	10kc
0.5μs	cw	> 5. μs	0.5μs	10kc
5μs	ccw	≲ 5μs	0.5μs	1kc
5μs	cw	> 50μs	5μs	1kc
0.05ms	ccw	≲ 50μs	5μs	0.1kc
0.05ms	cw	> 0.5ms	50μs	0.1kc
0.5ms	ccw	≲ 0.5ms	50μs	0.1kc
0.5ms	cw	> 5ms	0.5ms	10cps

4.4.6 Pulse Width Calibration

Pulse width is measured from the 50% point on the leading edge to the corresponding point on the lagging edge. Pulse width calibration accuracy is defined for output pulse rise time of 10 ns.

a) Set PULSE DELAY to 0.05 μs, VERNIER Counterclockwise. Pulse spacing $\frac{1}{\text{Repetition rate}}$ must be kept at 10 times the pulse width during calibration.

b) Adjust PULSE WIDTH according to the following chart: the wide upper limit calibration points assure that the ranges overlap to provide continuous coverage.

TABLE 4-6
WIDTH CALIBRATION ADJUSTMENTS

Width Range	Vernier Position (R100)	Adjustment	Set Width For	Scoop Sweep Speed	Rep. Rate
0.02μs	ccw	0.05μs LL(R149)	25ns	20ns	0.1mc
0.05μs	cw	0.05μs UL(R148)	0.52μs	0.1μs	0.1mc
0.5μs	ccw	0.5μs LL(R147)	0.5μs	0.1μs	10kc
0.5μs	cw	0.5μs UL(R146)	5.2μs	0.5μs	10kc
5μs	ccw	5μs	5μs	0.5μs	1kc

3. Recheck pulse width according to Table 4-7. It may be necessary to compromise the adjustment of R145 (5μs LL) such that the lower limit of the 0.05ms and 0.5ms ranges is within specification.

   It may be necessary to compromise the adjustment of R146 (0.5μs UL) such that the upper limit of the 5μs, 0.05ms and 0.5ms ranges is within specification.

TABLE 4-7
CHECK OF WIDTH CALIBRATION ADJUSTMENTS

Width Range	Vernier Position (R100)	Width $\lessgtr$ $^{+0\%}_{-5\%}$	Scope Sweep Speed (per cm)	Rep. Rate
0.02μs	ccw	$\lessgtr$ 25ns	20ns	0.1mc
0.05μs	cw	> 0.5μs	0.1μs	0.1mc
0.5μs	ccw	$\lessgtr$ 0.5μs	0.1μs	10kc
0.5μs	cw	> 5μs	0.5μs	10kc
5μs	ccw	$\lessgtr$ 5μs	0.5μs	1kc
5μs	cw	> 5μs	5μs	1kc
0.05ms	ccw	$\lessgtr$ 50μs	5μs	0.1kc
0.05ms	cw	> 0.5ms	50μs	0.1kc
0.5ms	ccw	$\lessgtr$ 0.5ms	50μs	0.1kc
0.5ms	cw	> 5ms	0.5ms	10cps

4.4.7 Output Circuit Calibration

NOTE: For optimum performance, calibration of the output circuits require the use of a high bandpass oscilloscope such as the HP Model 185B. The rise time and pulse corner frequencies are sufficiently above the response of a general purpose oscilloscope; therefore, waveform abberations may be present which will not be apparent when viewed on the slower scope. A general purpose oscilloscope is, however, sufficient for "coarse" adjustment. The adjustment procedure is as follows:

a) Set REPETITION RATE control to EXT.

b) Connect a dc voltmeter from TP 10 to ground and adjust R272 (positive overshoot) for a reading of +

c) Connect meter from TP 11 to ground and adjust R302 (neg. overshoot) for a reading of -11.8v.

d) Remove meter and set REPETITION RATE control to 0.1 mc, VERNIER fully clockwise.

   a) set in 0.1μs delay
   b) set width for 0.2μs
   c) set ATTENUATOR controls fully clockwise
   d) set TRANSITION TIME control to 10 μs, VERNIER fully ccw

e) Sync oscilloscope from positive sync output, sweep speed to 50 ns/cm, and view the positive output pulse terminated into 50 ohms.

f) Adjust R215 (pos. 10v output) for 12v amplitude.*

g) Adjust R272 (positive overshoot) for "squarest" leading corner and minimum overshoot.** The amount of adjustment should be very slight. At the correct adjustment the voltage at TP 10 should be approximately +11.5v. DO NOT VARY MORE THAN 1/4 TURN IN ANY DIRECTION.

h) View negative pulse output terminated into 50 ohms.

i) Adjust R240 (neg. 10v output) for 12v amplitude.*

j) Adjust R302 (neg. overshoot) for "squarest" leading corner and minimum overshoot.** The correct adjustment will give approximately -11.8v at TP 11.

k) This completes "coarse" calibration of the output driver. For fine tuning repeat 5 through 10 using HP 185B oscilloscope or equivalent.

This completes calibration adjustment procedure for the DATAPULSE Model 106 Pulse Generator.

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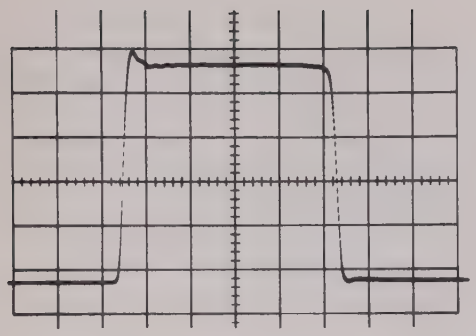
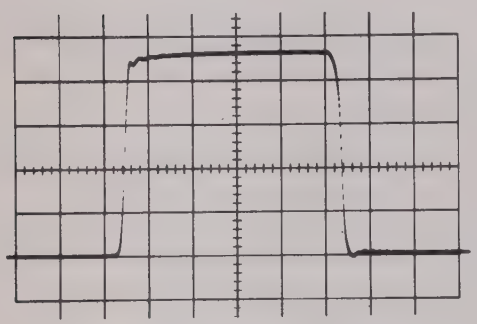
* This adjustment should be made to an accuracy of ±5%. Too great an amplitude will cause saturation of the output drivers on wide pulses.

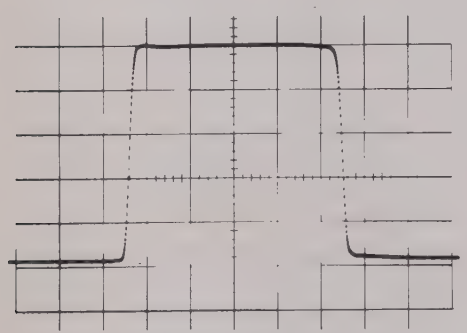
** This adjustment is very critical as too high a voltage will cause high dissipation of transistors in driver while too low a voltage will cause saturation of the output, see Figure 4-4.



a) R272 (Positive Overshoot) set too high. Note nearly 10% overshoot with full amplitude pulse.



b) R272 set too low. Note reduced amplitude, ring at leading corner, and droop-off, caused by storage time, at lagging corner.



c) Correct setting of R272. Note distinct corners on waveform and relative absence of aberrations.

Figure 4-4. Adjustment of R272 (Positive Overshoot) Photographed from Hewlett-Packard Model 185B Sampling Oscilloscope. 50 ns/cm and 2v/cm.

4.5 SPECIFICATIONS VERIFICATION

The following detailed test was performed on this instrument, just prior to shipment, to confirm published specifications. Before the test was conducted, the instrument was aged for a 24 hour period, and had undergone rigid examination for workmanship and appearance.

This test should be performed after every 200 hours of operation to confirm calibration status. Recalibrate and/or troubleshoot the instrument if the specifications are not verifiable.

4.5.1 Equipment Required

a) Oscilloscope, Hewlett-Packard 175A or equivalent (general purpose)

b) Oscilloscope, Hewlett-Packard 185B or equivalent (high-band pass)

c) Two 50-ohm terminations

d) One 20-db coaxial attenuator

e) Trigger generator (10 mc)

4.5.2 Repetition Rate

4.5.2.1 Oscillator Timing:

a) Set PULSE DELAY to 0.05μs, VERNIER ccw

b) Set PULSE WIDTH to 0.05μs, VERNIER ccw

c) Set TRANSITION TIME to 10 ns, VERNIERS ccw

d) Set ATTENUATORS to 10v, VERNIER cw

e) Terminate outputs into 50Ω load

f) Sync scope from pos. sync output

g) View pos. output pulse and follow the panel control settings in Table 4-8

TABLE 4-8
REPETITION RATE CALIBRATION VERIFICATION

Rep. Rate Range	Vernier Position	Pulse Width	Sweep Speed (per cm)	Pulse Spacing	Tolerance
0.1kc	ccw	5ms	100ms	>100ms (10cps)	Absolute
0.1kc	cw	.5ms	10ms	10ms (0.1kc)	±5%
1kc	ccw	.5ms	10ms	>10ms (0.1kc)	Absolute
1kc	cw	50μs	1ms	1ms (1kc)	±5%
10kc	ccw	50μs	1ms	>1ms (1kc)	Absolute
10kc	cw	5μs	100μs	.1ms (10kc)	±5%
0.1mc	ccw	5μs	100μs	>.1ms (10kc)	Absolute
0.1mc	cw	.5μs	10μs	10μs (.1mc)	±5%

CONTINUED

TABLE 4-8 CONTINUED

1mc	ccw	.5μs	10μs	>10μs (.1mc)	Absolute
1mc	cw	50ns	1μs	1μs (1mc)	±5%
12mc	ccw	50ns	1μs	1μs (1mc)	±5%
12mc	cw	50ns	.1μs	.0835μs (10mc)	±5%

4.5.2.2 Jitter:

a) Set controls as in 4.5.2.1, (a thru f) above

b) Set REPETITION RATE to 12 mc, VERNIER full cw

c) Set Sweep Speed to 0.1μs/cm

d) View pos. output pulse terminated into 50Ω load. One pulse should appear for each .835 cm. View the 10th pulse and expand sweep to 10ns/cm. The jitter should be less than 0.1cm, (0.1%).

4.5.2.3 Stability: Leave setup as in paragraph 4.5.2.2. Vary input voltage from 105v ac to 125 v ac. The shift should be less than 1 cm (1%).

4.5.2.4 External Triggering: Apply a ±5v signal from trigger generator to the external trigger input jack and verify that instrument can be slaved up to 10 mc with repetition rate control in both Ext. + and Ext. - positions.

4.5.2.5 Sync Pulse:

a) Set DELAY and WIDTH to minimum

b) View pos. sync pulse output into 100Ω load

c) Sweep REPETITION RATE from 1 mc to 10 mc

d) Sync Pulse amplitude should not vary over 2v. Note, amplitude is greater than 5v.

4.5.2.6 External Gate:

a) Set REPETITION RATE to 10 mc

b) View pos. output pulse

c) Apply a square wave of -5v in amplitude to "external gate" input jack with a repetition rate of 100 kc

d) Observe that output pulses occur only during negative portion of square wave.

4.5.3 Pulse Delay

4.5.3.1 Delay Timing:

a) Set Pos. and Neg. ATTENUATORS to 12v, VERNIERS cw

b) Set TRANSITION TIME to 10 ns, VERNIERS ccw

c) Set REPETITION RATE to 0.1 mc, VERNIERS cw

d) Sync oscilloscope from positive sync output

e) View the sync pulse and positive pulse output (50Ω termination) simultaneously on dual trace oscilloscope

f) Follow control settings in Table 4-9

4.5.3.2 Delay Duty Cycle:

a) Set REPETITION RATE to 0.1 mc, VERNIER cw

b) Set PULSE WIDTH to 0.05μs, VERNIER cw

c) Sync scope from positive sync output with sweep apeed of 1μs/cm

d) View positive pulse output (50Ω termination)

e) Set DELAY to 0.5μs, VERNIER ccw. Slowly turn VERNIER cw and verify that 50% delay duty cycle (5μs) can be attained without circuit failure.

4.5.3.3 Delay Jitter:

a) With controls set as in paragraph 4.5.3.2, (5μs Delay). Set sweep speed to 0.5μs/cm and expand to 50 ns/cm.

b) View leading edge of pulse and verify that jitter is less than 0.1 cm (0.1%).

4.5.3.4 Delay Stability: With same setup as paragraph 4.5.3.3, vary input voltage from 105v to 125v and verify that delay change is less than 1 cm (1%)

TABLE 4-9
DELAY CALIBRATION VERIFICATION

Delay Range	Vernier Position	Pulse Width	Rep. Rate	Sweep Speed (per cm)	Delay	Tolerance
0.05μs	ccw	50ns	0.1mc	50ns >	50ns (1cm)	Approx
0.05μs	cw	50ns	0.1mc	50ns	0.5μs (10cm)	Abs.
0.5μs	ccw	0.5μs	10kc	50ns	0.5μs (10cm)	±0.5cm
0.5μs	cw	0.5μs	10kc	.5μs >	5μs (10cm)	Abs.
5μs	ccw	5μs	1kc	.5μs	5μs (10cm)	±0.5cm
5μs	cw	5μs	1kc	5μs >	50μs (10cm)	Abs.
0.05ms	ccw	0.05ms	0.1kc	5μs	50μs (10cm)	±0.5cm
0.05ms	cw	0.05ms	0.1kc	50μs >	0.5ms (10cm)	Abs.
0.5ms	ccw	0.5ms	0.1kc	50μs	0.5ms (10cm)	±0.5cm
0.5ms	cw	0.5ms	10cps	.5ms >	5ms (10cm)	Abs.

4.5.4 Pulse Width

4.5.4.1 Pulse Width Timing:

a) Set ATTENUATORS to 10v, VERNIERS cw

b) Set TRANSITION TIME to 10 ns, VERNIERS ccw

c) Set REPETITION RATE to 0.1 mc, VERNIER cw

d) Sync Oscilloscope from positive sync output

e) View the positive pulse output (50Ω termination)

f) Follow control settings on Table 4-10

TABLE 4-10

WIDTH CALIBRATION VERIFICATION

Width Range	Vernier Position	Pulse Delay	Rep. Rate	Sweep Speed (per cm)	Tolerence	Width
0.05μs	ccw	50ns	0.1mc	20ns	Approx	25ns
0.05μs	cw	50ns	0.1mc	50ns	Absolute >	0.5μs (10cm)
0.5μs	ccw	0.5μs	10kc	50ns	±0.5cm	0.5μs (10cm)
0.5μs	cw	0.5μs	10kc	.5μs	Absolute >	5μs (10cm)
5μs	ccw	5μs	1kc	.5μs	±0.5cm	5μs (10cm)
5μs	cw	5μs	1kc	5μs	Absolute >	50μs (10cm)
0.05ms	ccw	0.05ms	0.1kc	5μs	±0.5cm	50μs (10cm)
0.05ms	cw	0.05ms	0.1kc	50μs	Absolute >	0.5ms (10cm)
0.5ms	ccw	0.5ms	0.1kc	50μs	±0.5cm	0.5ms (10cm)
0.5ms	cw	0.5ms	10cps	.5ms	Absolute >	5ms

4.5.4.4 Pulse Width Stability: With the same set-up as paragraph 4.5.3.3 vary line voltage from 150v to 125v and verify that pulse width change is less than 1cm (1%).

4.5.4.2 Pulse Width Duty Cycle:

a) Set REPETITION RATE to 0.1 mc, VERNIER cw

b) Set PULSE DELAY to 0.05μs, VERNIER cw

c) Sync scope from positive sync output with sweep speed of 1μs/cm

d) View positive pulse output (50Ω termination

e) Set PULSE WIDTH to 0.5μs, VERNIER ccw. Slowly turn VERNIER cw and verify that 50% WIDTH duty cycle (5μs) can be attained without circuit failure.

4.5.4.3 Pulse Width Jitter:

a) With controls set as in paragraph 4.5.4.2, (5μs Pulse Width). Set sweep speed to 0.5μs/cm and expand to 50ns/cm.

b) View lagging edge of pulse and verify that jitter is less than 0.1 cm (0.1%).

4.5.5 Main Pulse Output

4.5.5.1 Transition Time:

a) View POSITIVE PULSE terminated into 50 ohms

b) Check the upper and lower end of each range at the transition time control as shown in Table 4-11.

TABLE 4-11

TRANSITION TIME VERIFICATION

Frequency	Pulse* Width	Range	Leading Edge Control		Trailing Edge Control		Sweep Speed
			Max. ccw	Max. cw	Max. ccw	Max. cw	Min. Max.
100kc	0.5μs	10ns	≤ 10ns**	Approx 100ns	≤ 10ns**	Approx 100ns	10ns/cm .1μs/cm
10kc	5μs	0.1μs	< 0.1μs	Approx. 1 μs	<0.1μs	Approx 1μs	.1μs/cm 1μs/cm
1kc	50μs	1μs	< 1μs	Approx 10μs	< 1μs	Approx 10μs	1μs/cm 10μs/cm
100cps	500μs	10μs	< 10μs	Approx 100μs	<10μs	Approx 100μs	10μs/cm 100μs/cm
10cps	5ms	0.1ms	< 0.1ms	Approx 1ms	<0.1ms	Approx 1ms	.1ms/cm 1ms/cm

* On pulse width, use vernier ccw for minimum rise measurement and vernier cw for maximum rise measurement.

** 10 ns rise time may be measured better on high bandpass oscillosope later in this procedure.

3. View neg. pulse terminated into 50 ohms.
4. Repeat step (b) above.

4.5.5.2 Output Wave Shape:

a) Set REPETITION RATE for 100 kc
b) Set PULSE DELAY for 0.2μs
c) Set PULSE WIDTH for 0.2μs
d) Set TRANSITION TIMES for 10 ns
e) Set ATTENUATORS for 12v
f) Connect positive pulse output through a 20 db (10:1) coaxial attenuator into a 50Ω load
g) Set neg. attenuator to 0.4v
h) View voltage across load with high band-pass oscilloscope (HP185B or equivalent)
i) Set sweep speed 50 ns/cm
j) Set vertical sensitivity 0.2v/cm (10:1 attenuator makes 2v/cm effective) See Fig. 4-5.
k) Verify that amplitude is 6 cm ±1/2 cm (5%)
m) Verify that pulse aberrations are less than 0.24 cm (4%)
n) Set sweep speed to 10ns/cm
o) View leading edge and verify that rise time from 10% to 90% amplitude points is less than 10 nanoseconds (1 cm)
p) View lagging edge and verify that decay time from 90% to 10% amplitude points is less than 10 nanoseconds (1 cm)
q) Set pos. attenuator to 0.3v. Set neg. attenuator to 10 volts. Connect neg. pulse output through 20db (10 : 1) attenuator to 50 ohm load
r) Repeat steps h through p

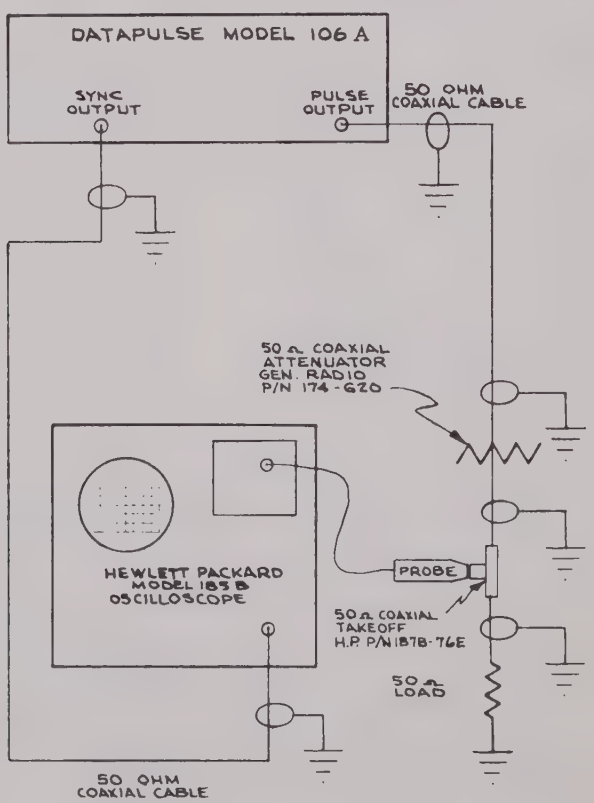

DATAPULSE MODEL 106 A
SYNC OUTPUT
PULSE OUTPUT
50 OHM COAXIAL CABLE
50 Ω COAXIAL ATTENUATOR GEN. RADIO P/N 174-GZO
HEWLETT PACKARD MODEL 185 B OSCILLOSCOPE
PROBE
50 Ω COAXIAL TAKEOFF H.P. P/N 187B-76E
50 Ω LOAD
50 OHM COAXIAL CABLE

Figure 4-5. Scope Interconnections for Waveform Verification

SECTION V

PARTS LIST

5.1 HOW TO USE THIS PARTS LIST

5.1.1 Reference Designations

Reference designations used throughout this listing correspond with reference designations given on component location photos and the following schematics:

Drawing No. 40000-042, Revision D
Drawing No. 40000-043

Resistors are designated as R1, R2, R3, etc., and are fixed value, composition, 10% and 1/2w unless otherwise noted.

Capacitors are designated as C1, C2, C3, etc., and are fixed value, 10%, 500v dc unless otherwire noted.

Diodes are designated as CR1, CR2, CR3; switches as S1, S2, S3; inductors as L1, L2, and L3 etc.

5.1.2 Abbreviations

The following abbreviations are used:

CER	- Ceramic
DPC	- Deposited Carbon
ELECT	- Electrolytic
M	- Mica
MP	- Metalized Paper
GMV	- Guaranteed Min. Value
OF	- Oil Filled
PT	- Paper Tubular
SM	- Silver Mica
VAR	- Var.
WW	- Wire Wound
VTQ	- Vitamin Q
PNP	- Positive-Negative-Positive
NPN	- Negative-Positive-Negative
μsec	- Microsecond
μf	- Microfarad
μh	- Microhenry
ns	- Nanosecond
ms	- Millisecond

5.1.3 Federal Manufacturers Code Numbers

Manufacturers of the components used in this instrument are referenced herein by Federal Supply Code numbers as given in the October 1959 issue of Department of Defense Cataloging Handbook H4-1 and H4-2, available from the Armed Forces Supply Support Center, Washington, D. C.

5.2 RESISTORS

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES
R1	4	560Ω, 5%	10011-561	01121	EB5615	
R2	1	430Ω, 5%	10011-431	01121	EB4315	
R3	13	1.5k, 5%	10011-152	01121	EB1525	
R4	2	390Ω, 5%	10011-391	01121	EB3915	
R5	11	1k,	10011-102	01121	EB1025	
R6	2	750Ω, 5%	10011-751	01121	EB7515	
R7	4	820Ω, 5%	10011-821	01121	EB8215	
R8	6	10Ω, 5%	10011-100	01121	EB1005	
R9	24	47Ω, 5%	10011-470	10021	EB4705	
R10		Same as R3				
R11	6	2.7k, 5%	10011-272	01121	EB2725	
		R 12 thru R24 Not Used				
R25	1	Same as R6				
R26	5	VAR., 250k, 0.2w, 30%	20240-254	71450	UPE70	
R27	5	VAR., 2.5k, 0.2w, 30%	20240-252	71450	UPE70	
R28	1	VAR., 100k, 0.2w, 30%	20240-104	71450	UPE70	
R29		Same as R27				
R30		Same as R27				
R31		Same as R27				
R32		Same as R27				
R33	5	4.7k, 5%	10011-472	01121	EB4725	
R34	1	VAR., 5k, 2w	20053-502	01121	JAIN056S-502UA	
R35	3	15k, 5%	10011-153	01121	EB1535	
R36	1	VAR., 100k, 2w	20053-104	01121	JAIN056S-104UA	
R37	10	100Ω, 5%	10011-101	01121	EB1015	
R38		Not Used				
R39		Same as R5				

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES
R40		Same as R7				
R41		470Ω, 5%	10011-471	01121	EB4715	
R42	3	3.9k, 5%	10011-392	01121	EB3915	
R43		Same as R3				
R44		Same as R41				
R45		Same as R11				
R46	7	51Ω, 5%	10011-510	01121	EB5105	
R47	5	10k, 5%	10011-103	01121	EB1035	
R48		Same as R46				
R49	2	100k, 5%	10011-104	01121	EB1045	
R50	4	330Ω, 5%	10011-331	01121	EB3315	
R51	1	1.2k, 1w, 5%	10012-122	01121	GB1225	
R52		Same as R35				
R53		Same as R9				
R54	5	1.8k, 5%	10011-182	01121	EB1825	
R55		Same as R9				
R56		Same as R37				
R57		Same as R33				
R58		Same as R9				
R59		Same as R42				
R60		Same as R1				
R61		Same as R54				
R62	3	3.3k, 5%	10011-332	01121	EB3325	
R63		Same as R33				
R64	1	100Ω, 1w, 5%	10012-101	01121	GB1015	
R65		Same as R37				
R66		Same as R62				
R67		Not Used				
R68		Not Used				
R69		Not Used				
R70	6	27k, 5%	10011-273	01121	EB2735	
R71		Same as R35				
R72	4	2.2k, 5%	10011-222	01121	EB2225	
R73		Same as R37				
R74		Same as R54				
R75	5	22Ω, 5%	10011-220	01121	EB2205	
R76		Same as R37				
R77		Same as R3				
R78		Same as R75				
R79		Same as R70				
R80	2	750Ω, 1w, 5%	10012-751	01121	GB7515	
		R81 thru R94 Not Used				
R95	6	VAR., 0.2w, 30%	20240-103	71450	UPE70	
R96		Same as R26				
R97		Same as R95				
R98		Same as R26				
R99		Same as R95				
R100	2	VAR., 150k, 2w	20053-154	01121	JAIN056S-154UA	
R101	3	47k, 5%	10011-473	01121	EB4735	
		R102 thru R109 Not Used				
R110	7	680Ω, 5%	10011-681	01121	EB6815	
R111	1	180Ω, 5%	10011-181	01121	EB1815	
R112		Not Used				
R113		Not Used				
R114		Same as R75				
R115		Same as R41				
R116		Same as R11				
R117		Same as R4				
R118		Same as R50				
R119		Same as R3				
R120		Same as R70				

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES
R121	1	7.5k, 5%	10011-751	01121	EB7525	
R122		Same as R72				
R123		Same as R37				
R124		Same as R5				
		R125 thru R129 Not Used				
R130		Same as R37				
R131		Same as R54				
R132		Same as R75				
R133		Same as R3				
R134		Same as R8				
R135		Same as R70				
		R136 thru R144 Not Used				
R145		Same as R95				
R146		Same as R26				
R147		Same as R95				
R148		Same as R26				
R149		Same as R95				
R150		Same as R100				
R151		Same as R101				
		R152 thru R159 Not Used				
R160		Same as R54				
R161		Same as R75				
R162		Same as R5				
R163		Same as R110				
		R164 thru R200 Not Used				
R201		Same as R9				
R202		Same as R47				
R203		Same as R70				
R204		Same as R9				
R205	2	VAR., 25k, 2w	20053-253	01121	JAIN056S-253UA	
R206		Same as R5				
R207		Same as R205				
R208		Same as R9				
R209		Same as R9				
R210		Same as R70				
R211		Same as R8				
R212	1	120Ω, 5%	10011-121	01121	EB1215	
R213		Same as R37				
R214		Same as R9				
R215	7	VAR., 1k, 0.2w, 30%	20240-102	71450	UPE70	
R216		Same as R3				
R217		Same as R8				
R218		Same as R42				
R219		Same as R9				
R220		Same as R11				
R221		Same as R5				
R222	2	33k	10021-333	01121	EB3331	
R223		Same as R222				
R224		Not Used				
R225		Not Used				
R226		Not Used				
R227		Not Used				
R228		Not Used				
R229		Not Used				
R230		Same as R9				
R231		Same as R8				
R232		Same as R101				
R233		Same as R5				
R234		Same as R11				
R235	6	220Ω, 5%	10011-221	01121	EB2215	
R236		Same as R8				

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES
R237		Same as R235				
R238		Same as R235				
R239		Same as R37				
R240	1	VAR., 250Ω, 0.2w, 30%	20240-251	71450	UPE70	
R241		Same as R7				
R242		Same as R8				
		R243 thru R250 Not Used				
R251	2	33k, 5%	10011-153	01121	EB3335	
R252		Same as R9				
R253		Same as R11				
R254		Same as R7				
R255		Same as R9				
R256		Same as R9				
R257		Same as R9				
R258		Same as R9				
R259		Same as R9				
R260		Same as R46				
R261	10	1.8k	10021-182	01121	EB1821	
R262		Same as R46				
R263		Same as R261				
R264		Same as				
R265		Same as R261				
R266		Same as R46				
R267		Same as R261				
R268		Same as R261				
R269		Same as R46				
R270		Same as R62				
R271		Same as R3				
R272		Same as R215				
R273		Same as R110				
R274		Same as R235				
		R275 thru R280 Not Used				
R281		Same as R251				
R282		Same as R9				
R283		Same as R5				
R284		Same as R110				
R285		Same as R9				
R286		Same as R9				
R287		Same as R9				
R288		Same as R9				
R289		Same as R9				
R290	5	68Ω	10021-680	01121	EB6801	
R291		Same as R261				
R292		Same as R240				
R293		Same as R261				
R294		Same as R240				
R295		Same as R261				
R296		Same as R240				
R297		Same as R261				
R298		Same as R261				
R299		Same as R240				
R300		Same as R3				
R301		Same as R3				
R302		Same as R215				
R303		Same as R110				
R304		Same as R37				
R305		Same as R235				
		R306 thru R409 Not Used				

PARTS LIST

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
R410	2	Dual 50Ω, 2w, 20%	20213-500S				
R411	2	51Ω, 2w, 5%, Mt. Film	10723-510	07115	C2		
R412		Not Used					
R413	2	51Ω, 5%	10011-510	01121	EB5105		
R414	12	24Ω, 2w, 5%	10013-240	01121	HB2405		
R415	6	36Ω, 2w, 5%	10013-360	01121	HB3605		
R416		Same as R414					
R417	8	27Ω, 2w, 5%	10013-270	01121	HB2705		
R418	4	33Ω, 2w, 5%	10013-330	01121	HB3305		
R419		Same as R417					
R420		Same as R414					
R421		Same as R415					
R422		Same as R414					
R423		Same as R417					
R424		Same as R418					
R425		Same as R417					
R426		Same as R414					
R427		Same as R415					
R428		Same as R414					
R429 through R439		Not Used					
R440		Same as R410					
R441		Same as R411					
R442		Same as R413					
R443		Same as R414					
R444		Same as R415					
R445		Same as R414					
R446		Same as R417					
R447		Same as R418					
R448		Same as R417					
R449		Same as R414					
R450		Same as R415					
R451		Same as R414					
R452		Same as R417					
R453		Same as R418					
R454		Same as R417					
R455		Not Used					
R456		Same as R414					
R457		Same as R415					
R458		Same as R414					

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES
		R459 thru R500 Not Used				
R501		Same as R49				
		R502 thru 509 Not Used				
R510	2	5Ω, 5w, 5%	10304-509	63743	SF5WL	
R511	2	200Ω, 5w, 5%, ww	10304-201	63743	SF200WL	
R512		Same as R110				
R513		Same as R47				
R514		Same as R33				
R515		Same as R41				
R516		Same as R215				
R517		Same as R5				
R518		Same as R3				
R519		Same as R3				
R520	1	1.2k, 5%	10011-122	01121	EB1225	
R521		Same as R72				
R522		Same as R215				
R523		Same as R50				
R524		Same as R1				
R525	1	100Ω, 10w, 5%, ww	10305-101	06136	10F150WL	
R526		Not Used				
R527		Not Used				
R528		Not Used				
R529		Not Used				
R530		Same as R511				
R531		Same as R510				
R532		Same as R110				
R533		Same as R47				
R534		Same as R33				
R535		Same as R41				
R536		Same as R215				
R537		Same as R5				
R538		Same as R72				
R539		Same as R215				
R540		Same as R50				
R541		Same as R5				
R542		Same as R1				
R543		Same as R3				
R544		Same as R9				
R545	1	250Ω, 5w, 5%, ww	10304-251	63743	SF250WL	
R546	2	18Ω, 1w, 5%	10012-180	01121	GB1805	
R547	1	300Ω, 5w, 5%, ww	10304-301	63743	SF300WL	
R548		Same as R546				
R549		Same as R47				
R550		Same as R235				

PARTS LIST

5.3 CAPACITORS

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
C1	34	0.1 µf, 75v, +80%, -20% Fxd. Cer. Disc	11242-104	71590	DDA-104		
C2		Same as C1					
C3		Same as C1					
C4	1	4-30 pf, Var. Cer.	11307-300	91674	503-000		
C5	1	1000 pf, 1%	11027-102	00853	CR1210		
C6	1	0.01 µf, 300v, 1%	10025-103	00853	CR1110F		
C7	1	0.1 µf, 100v, 1%, Fxd. Met. Mylar	11093-104	14752	Type 250		
C8	1	1 µf, 100v, 1%, Fxd. Met. Mylar	11093-105	14752	Type 250		
C9	1	10 µf, 20v, Fxd. Tant	11511-106	56289	150D-106X9020B2		
C10		Same as C1					
C11	2	27 pf, 5%, S.M.	11017-270	00853	RR1427		
C12	1	39 pf, 5%, S.M.	11017-390	00853	RR1439		
C13	18	0.01 µf, +80%, -20%	11247-103	91674	841-.01		
C14 through C19		Not Used					
C20	1	1 µf, 50v, Elect.	11152-105		EG81-50P		
C21	2	470 pf, 300v, 5%	11015-471	00853	RR06347		
C22		Same as C1					
C23	1	20 µf, 50v	11152-510	56289	TE1305		
C24 through C39		Not Used					
C40		Same as C1					
C41		Same as C11					
C42		Same as C1					
C43 through C49		Not Used					
C50	2	100 pf, 5%	11017-101	00853	DR1310		
C51		Same as C1					
C52		Same as C1					
C53		Same as C1					
C54		Same as C1					
C55		Same as C1					
C56		Same as C13					
C57 through C69		Not Used					
C70	1	68 pf, 5%	11017-680	00853	RR1468		
C71		Same as C1					
C72		Same as C13					
C73	32	100 µf, 35v	11162-107	37942	35S8520-500BD-100		
C74		Same as C73					
C75		Same as C13					
C76	2	47 pf, 5%	11017-470	00853	RR1447		
C77	2	470 pf, 300v, 1%	11005-471	00853	RR06347F		
C78	2	4700 pf, 300v, 1%	11025-472	04062	CM20E-427F		
C79	2	0.047 µf, 200v, 1%, Fxd. Met. Mylar	11124-473	04099	Type MMW		
C80	2	0.47 µf, 200v, 1%, Fxd. Met. Mylar	11124-474	04099	Type MMW		
C81		Same as C1					
C82		Same as C1					
C83		Same as C1					
C84		Same as C13					
C85		Same as C73					
C86		Same as C73					
C87 through C110		Not Used					

PARTS LIST

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
C111		Same as C1					
C112		Same as C50					
C113 through C119		Not Used					
C120	1	82 pf, 5%	11017-820	00853	RR1482		
C121		Same as C1					
C122		Same as C76					
C123		Not Used					
C124		Same as C13					
C125		Same as C73					
C126 through C129		Not Used					
C130		Same as C76					
C131		Same as C77					
C132		Same as C78					
C133		Same as C79					
C134		Same as C80					
C135		Same as C1					
C136		Same as C73					
C137		Same as C13					
C138 through C159		Not Used					
C160		Same as C73					
C161		Same as C13					
C162		Same as C1					
C163		Same as C1					
C164 through C200		Not Used					
C201		Same as C73					
C202		Same as C13					
C203		Same as C13					
C204		Same as C73					
C205		Same as C1					
C206		Not Used					
C207		Same as C1					
C208		Not Used					
C209		Same as C1					
C210		Same as C1					
C211	3	10 pf, 5%	11017-100	00853	DR1410		
C212		Same as C21					
C213	1	4700 pf,	11037-472	02799	CM20E472J		
C214	1	0.047 µf, 200v	11114-473	09134	Type 31		
C215	1	0.47 µf, 200v	11114-474	09134	Type 31		
C216		Same as C13					
C217		Same as C73					
C218		Same as C13					
C219		Not Used					
C220		Same as C13					
C221		Same as C211					
C222		Same as C211					
C223		Same as C73					
C224 through C229		Not Used					
C230		Same as C13					
C231		Same as C73					
C232		Same as C13					
C233		Same as C73					
C234		Same as C1					

PARTS LIST

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
C235 through C 249 Not Used							
C250		Same as C1					
C251		Same as C73					
C252		Same as C13					
C253		Same as C13					
C254		Same as C73					
C255		Same as C1					
C256		Same as C1					
C257 through C263 Not Used							
C264		Same as C73					
C265		Same as C1					
C266 through C279 Not Used							
C280		Same as C1					
C281		Same as C73					
C282		Same as C13					
C283		Same as C13					
C284		Same as C73					
C285		Same as C1					
C286		Same as C1					
C287 through C293 Not Used							
C294		Same as C73					
C295		Same as C1					
C296 through C500 Not Used							
C501	2	0.1 µf, 400v, Paper Mylar	11066-104	02799	4DP-3-104		
C502		Same as C501					
C503 through C509 Not Used							
C510	3	1500 µf, 50v, Elect.	11162-158	00853	505-2236-02		
C511		Same as C73					
C512		Same as C510					
C513		Same as C73					
C514		Same as C73					
C515		Same as C73					
C516		Same as C73					
C517 through C529 Not Used							
C530		Same as C510					
C531		Same as C73					
C532		Same as C73					
C533		Same as C73					
C534		Same as C73					
C535		Same as C73					
C536		Same as C73					
C537		Same as C73					
C538		Same as C73					

PARTS LIST

5.4 TRANSISTORS

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
Q1	5	Silicon, PNP TO-5	22595-000	15933	DP 59-0		
Q2	37	Silicon, NPN, TO-18	22635-001	15933	DP 63-0 (MAY. 2N2222		
Q3		Not Used					
Q4		Not Used					
Q5		Same as Q2					
Q6	1	Silicon, NPN, TO-18	22635-003	15933	DP 63-3		
Q7		Same as Q2					
Q8	12	Silicon, PNP, TO-18	22605-003	15933	DP 60-3		
Q9		Same as Q8					
Q10		Same as Q8					
Q11		Same as Q2					
Q12		Same as Q8					
Q13		Same as Q2					
Q14		Same as Q2					
Q15		Same as Q2					
Q16		Same as Q2					
Q17		Same as Q2					
Q18		Same as Q2					
Q19		Same as Q2					
Q20		Same as Q2					
Q21		Same as Q2					
Q22		Same as Q2					
Q23		Same as Q2					
Q24		Same as Q2					
Q25		Not Used					
Q26		Same as Q8					
Q27		Same as Q2					
Q28		Same as Q8					
Q29		Same as Q2					
Q30		Same as Q2					
Q31		Same as Q2					
Q32		Same as Q2					
Q33		Same as Q2					
Q34		Same as Q2					
Q35		Same as Q2					
Q36		Same as Q2					
Q37		Same as Q2					
Q38		Same as Q2					
Q39		Same as Q2					
Q40		Same as Q2					
Q41		Same as Q2					
Q42	5	Silicon, PNP, TO-18	22605-001	15933	DP 60-1		
Q43		Same as Q42					
Q44		Same as Q42					
Q45		Same as Q42					
Q46		Same as Q42					
Q47		Same as Q1					
Q48		Same as Q8					
Q49		Same as Q8					
Q50		Same as Q8					
Q51		Same as Q8					
Q52		Same as Q8					
Q53		Same as Q8					
Q54		Same as Q2					
Q55		Same as Q2					
Q56		Same as Q2					
Q57		Same as Q2					
Q58		Same as Q2					
Q59	6	Silicon, NPN, TO-18	12685-004	94990	SM1330		

Q60 through Q500 Not Used

Q501	Same as Q1
Q502	Same as Q59

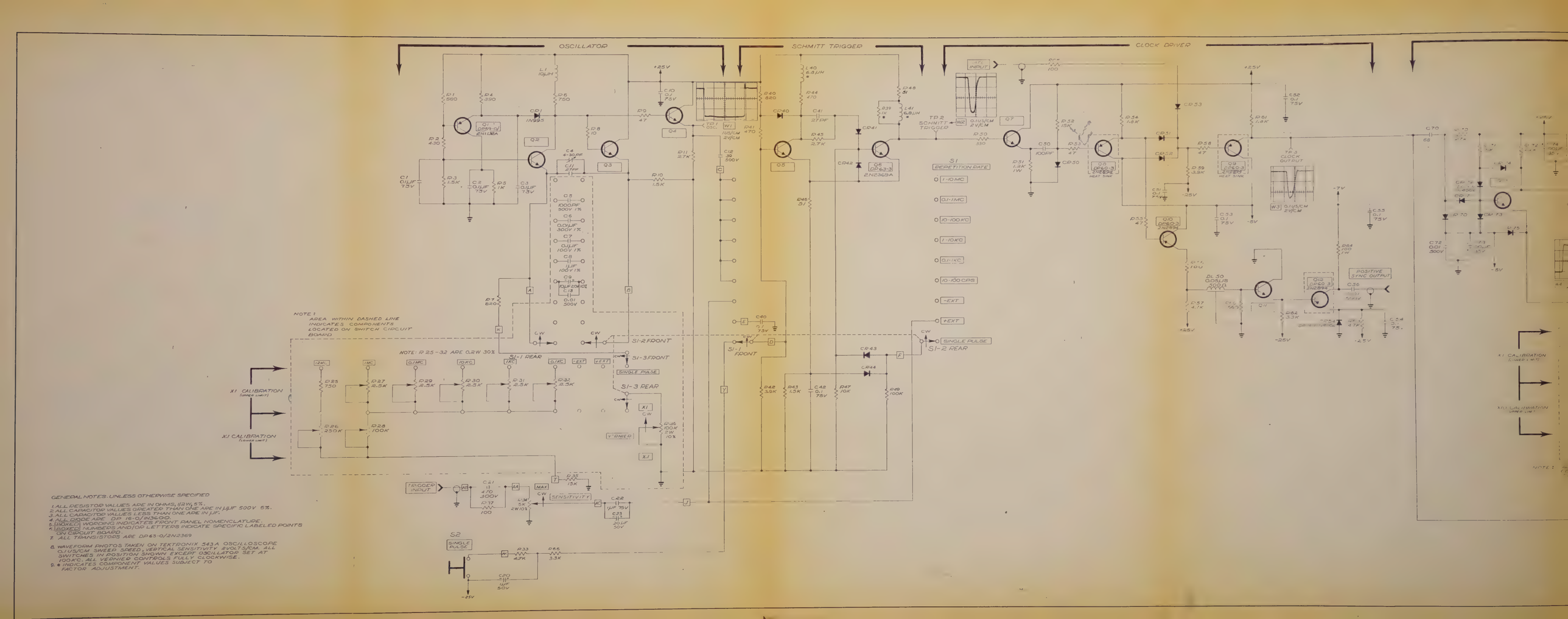
PARTS LIST

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
Q503	3	Germanium, PNP	12455-008	94990	2N1535		
Q504		Same as Q59					
Q505		Same as Q2					
Q506		Same as Q503					
Q507		Not Used					
Q508		Same as Q503					
Q509		Same as Q59					
Q510		Same as Q1					
Q511		Same as Q1					
Q512		Same as Q59					
Q513		Same as Q59					
5.5	DIODES						
CR1	9	Germanium - High Speed	12144-003	93332	1N995		
CR2 through CR39 Not Used							
CR40	45	Silicon, Mesa Computer	22164-000	15933	DP 16-0		
CR41		Same as CR40					
CR42		Same as CR40					
CR43		Same as CR40					
CR44		Same as CR40					
CR45 through CR49 Not Used							
CR50		Same as CR40					
CR51		Same as CR40					
CR52		Same as CR40					
CR53		Same as CR40					
CR54	21	Silicon, Power	12194-001	15933	DP 19-1		
CR55 through CR69 Not Used							
CR70		Same as CR40					
CR71		Same as CR40					
CR72		Same as CR54					
CR73		Same as CR40					
CR74		Same as CR40					
CR75		Same as CR40					
CR76		Same as CR40					
CR77		Same as CR40					
CR78 through CR117 Not Used							
CR118		Same as CR40					
CR119		Same as CR40					
CR120		Same as CR40					
CR121		Same as CR1					
CR122		Same as CR54					
CR123		Same as CR40					
CR124		Same as CR40					
CR125		Same as CR40					
CR126		Same as CR40					
CR127		Not Used					
CR128		Not Used					
CR129		Not Used					
CR130		Same as CR40					
CR131 through CR159 Not Used							

PARTS LIST

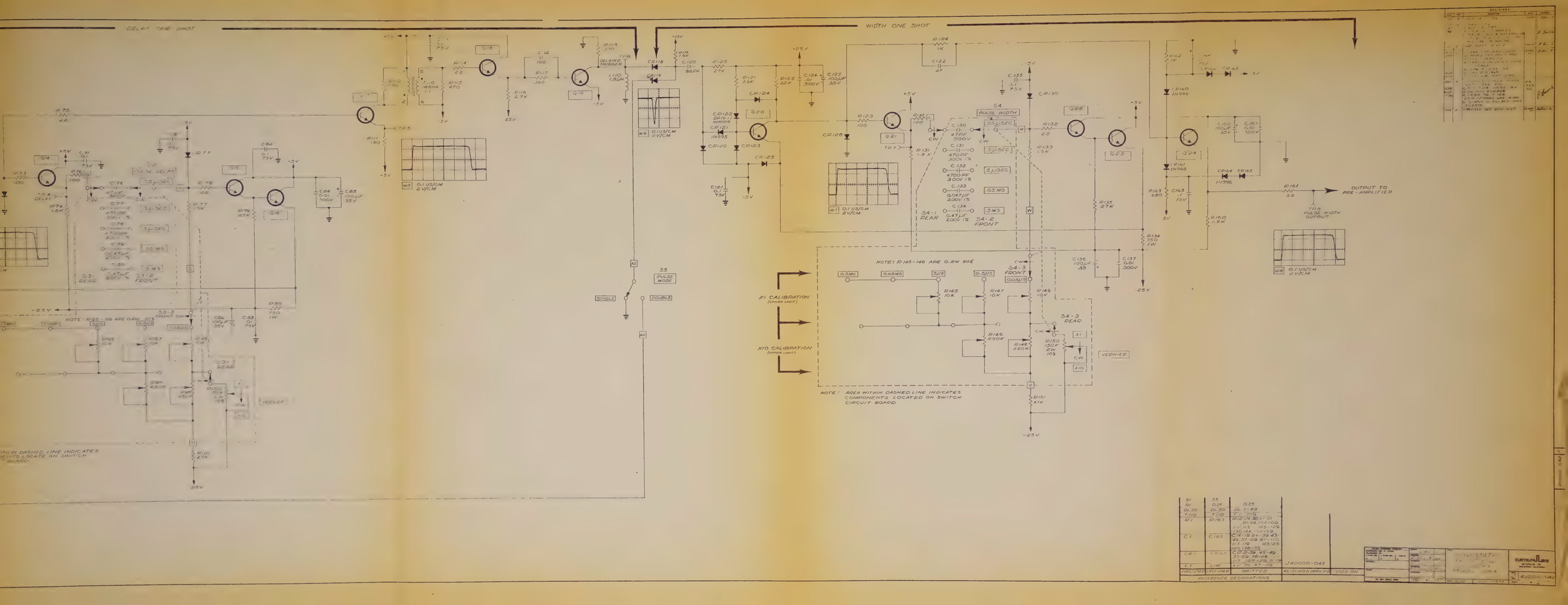
REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES	UNIT PRICE
CR160		Same as CR1					
CR161		Same as CR1					
CR162		Same as CR40					
CR163		Same as CR40					
CR164		Same as CR1					
CR165		Same as CR40					
CR166 through CR 200		Not Used					
CR201		Same as CR40					
CR202		Same as CR40					
CR203		Same as CR40					
CR204		Same as CR40					
CR205		Same as CR40					
CR206		Same as CR40					
CR207		Same as CR1					
CR208		Same as CR40					
CR209		Same as CR40					
CR210 through CR229		Not Used					
CR230		Same as CR40					
CR231		Same as CR40					
CR232 through CR249		Not Used					
CR250		Same as CR40					
CR251		Same as CR1					
CR252		Same as CR40					
CR253		Same as CR40					
CR254		Not Used					
CR255		Same as CR54					
CR256		Same as CR54					
CR257		Same as CR54					
CR258		Same as CR54					
CR259		Same as CR54					
CR260		Same as CR54					
CR261 through CR279		Not Used					
CR280		Same as CR40					
CR281		Same as CR40					
CR282		Same as CR1					
CR283		Same as CR1					
CR284		Not Used					
CR285		Same as CR54					
CR286		Same as CR54					
CR287		Same as CR54					
CR288		Same as CR54					
CR289		Same as CR54					
CR290 through CR509		Not Used					
CR510		Same as CR54					
CR511		Same as CR54					
CR512		Same as CR54					
CR513		Same as CR54					
CR514	2	Zener, 15v, 1w, 5%	12154-017	37942	ZA15B		
CR515 through CR529		Not Used					
CR530		Same as CR54					

REF. NO.	QTY. USED	DESCRIPTION	DATAPULSE PART NO.	FEDERAL MFRS. CODE NO.	MFRS. PART NO.	REC. SPARES
CR531		Same as CR54				
CR532		Same as CR54				
CR533		Same as CR54				
CR534		Same as CR514				
CR535		Same as CR40				
CR536		Same as CR40				
CR537		Same as CR40				
5.6	SWITCHES					
S1	1	Rotary, 9 pos., 3 sec. 30° conc	25250-016A	81716	231182J3	
S2	1	P.B., SPDT	15300-001	82389	903-1C Red	
S3	2	Rotary, 5 pos., 3 sec, 60° conc	25250-D17A	81716	231183N3-Rev.A	
S4		Same as S3				
S501	2	Toggle, SPDT	15280-001	95146	MST115D	
5.7	MISCELLANEOUS					
T110	1	Pulse Xfmer, 1: 1±5%	14165-002	T90095	1W6HA	
DL50	1	Delay Line, .05ms, 500Ω	14200-003	PCA Elect.	DL-500B-0.05	
L1	1	Inductor, 10μh	14284-003	99818	217-11-10	
L40	1	Inductor, 15μh	14284-000	99848	W68G	
L41	1	Inductor, 3.3μh	14284-332	99848	W33G	
L110	1	Inductor, 1.8μh	14284-004	99848	208-11-18	


OSCILLATOR
SCHMITT TRIGGER
CLOCK DRIVER
NOTE: 1
AREA WITHIN DASHED LINE INDICATES COMPONENTS LOCATED ON SWITCH CIRCUIT BOARD.
NOTE: R 25-32 ARE 0.2W 30%
S1-1 REAR
S1-2 FRONT
S1-3 FRONT
S1-3 REAR
S1-1 FRONT
S1-2 REAR
S1 REPETITION RATE
1-10 MC
0.1-1 MC
10-100 KC
1-10 KC
0.1-1 KC
10-100 CPS
-EXT
+EXT
SINGLE PULSE
V-DNIED
X1
X.1
X1 CALIBRATION (upper limit)
X.1 CALIBRATION (lower limit)
TRIGGER INPUT
SENSITIVITY
S2
SINGLE PULSE
TP 1 OSC.
TP 2 SCHMITT TRIGGER
TP 3 CLOCK OUTPUT
POSITIVE SYNC OUTPUT
DL 50 CD5118
+25V
-25V
-8V
-7V
-4.5V
GENERAL NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTOR VALUES ARE IN OHMS, 1/2W, 5%.
2. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN μμF 500V 6%.
3. ALL CAPACITOR VALUES LESS THAN ONE ARE IN μF.
4. ALL DIODE ARE DP 16-0/IN660.
5. BOXED WORDING INDICATES FRONT PANEL NOMENCLATURE.
6. BOXED NUMBERS AND/OR LETTERS INDICATE SPECIFIC LABELED POINTS ON CIRCUIT BOARD.
7. ALL TRANSISTORS ARE DP 63-0/2N2369
8. WAVEFORM PHOTOS TAKEN ON TEKTRONIX 343A OSCILLOSCOPE 0.1 US/CM SWEEP SPEED, VERTICAL SENSITIVITY 2VOLTS/CM. ALL SWITCHES IN POSITION SHOWN EXCEPT OSCILLATOR SET AT 100 KC. ALL VERNIER CONTROLS FULLY CLOCKWISE.
9. ◆ INDICATES COMPONENT VALUES SUBJECT TO FACTOR ADJUSTMENT.

DELAY ONE SHOT

WIDTH ONE SHOT



S1	S5	Q35
Q1	Q24	CR 149
CR30	CR30	T110
T110	D1	D102-04,38,57-66, 81-94,102-109, 112-115, 123-128, 130-144, 147-159
D1	D163	C4-19,24-32,43-49,57-69,87-110, 113-119, 123-126, 129,138-155
C1	C163	C102-39,45-49, 55-69,78-109, 117,137-149,3178
CR1	CR163	
L1	L10	1-30, 43-58
FIRST USED	LAST USED	OMITTED

ASSOCIATED DRWG NO. U40000-043

USED ON

REFERENCE DESIGNATIONS

REVISIONS			
LTR	DESCRIPTION	DATE	APPROVED
A			
B			
C			
D			
E			
F			
G			
H			
J			
K			
L			
M			
N			
P			
R			
S			
T			
U			
V			
W			
X			
Y			
Z			

DRAWN			
TRACED			
CHECKED			
ENGR APPR.			
MFG APPR.			

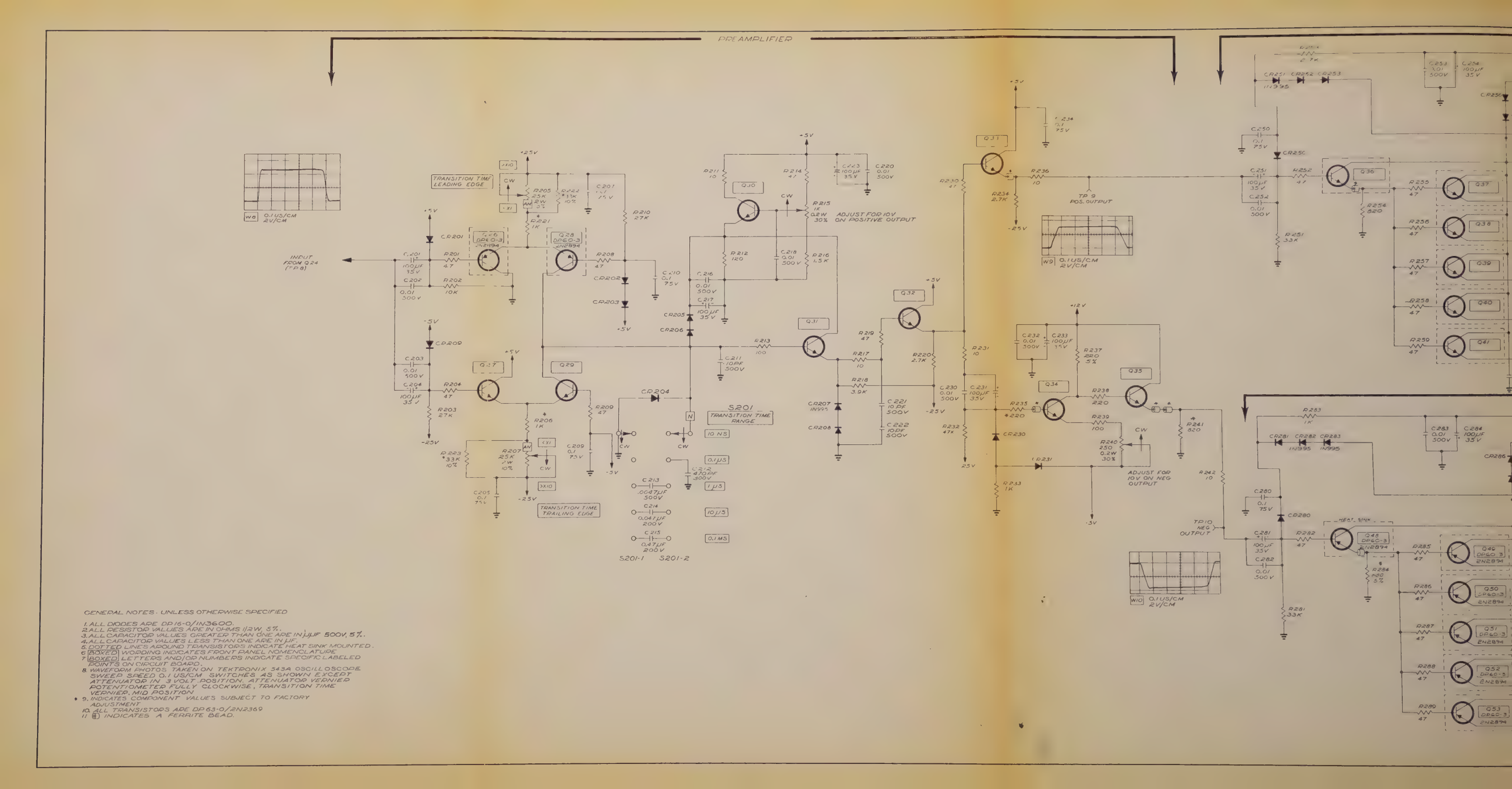
TEKTRONIX, INC. BEAVERTON, OREGON

SIZE	CODE IDENT. NO.	DRAWING NO.	REV
D	80009	040-0000-00	

SCALE NONE

WEIGHT

SHEET 2 OF 2



GENERAL NOTES: UNLESS OTHERWISE SPECIFIED

1. ALL DIODES ARE DP16-0/1N3600.
2. ALL RESISTOR VALUES ARE IN OHMS 1/2W, 5%.
3. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN µµF 500V, 5%.
4. ALL CAPACITOR VALUES LESS THAN ONE ARE IN µF.
5. DOTTED LINES AROUND TRANSISTORS INDICATE HEAT SINK MOUNTED.
6. [BOXED] WORDING INDICATES FRONT PANEL NOMENCLATURE.
7. [BOXED] LETTERS AND/OR NUMBERS INDICATE SPECIFIC LABELED POINTS ON CIRCUIT BOARD.
8. WAVEFORM PHOTOS TAKEN ON TEKTRONIX 543A OSCILLOSCOPE. SWEEP SPEED 0.1 US/CM. SWITCHES AS SHOWN EXCEPT ATTENUATOR IN 3 VOLT POSITION. ATTENUATOR VERNIER POTENTIOMETER FULLY CLOCKWISE, TRANSITION TIME VERNIER, MID POSITION.
9. • INDICATES COMPONENT VALUES SUBJECT TO FACTORY ADJUSTMENT.
10. ALL TRANSISTORS ARE DP63-0/2N2369
11. (B) INDICATES A FERRITE BEAD.

POSITIVE OUTPUT AMPLIFIER

+25V

CR258 CR259

...35 TO ...259 ARE DR9 1/1N4002

R260 51 C257

R262 51 C258

R264 51 C259

R266 51 C260

R269 51 C261

R261 1.8K 10%

R263 1.8K 10%

R265 1.8K 10%

R267 1.8K 10%

R268 1.8K 0%

ADJUST FOR MINIMUM OVERSHOOT AT 20S OUTPUT

R272 1K 0.2W

R271 1.5K

R273 680

R270 3.4K 5%

R274 220 5%

TP11

Q47 DP59-0

2N1132A

+5V

C264 100UF 35V

C265 0.1 75V

Q42 DP60-1

Q43 DP60-1

Q44 DP60-1

Q45 DP60-1

Q46 DP60-1

W11 PAD X 0.1US/CM 5V/CM

DECREASE

BRIDGE "T" PAD

R410B 50 2W

R411 51 2W 3%

R410A 50 2W

R413 51 3%

POSITIVE

AMPLITUDE WITH 50Ω TERMINATION

VOLTS

1.2 0.4 4.0 1.2 1.2 0.4

R414 24 2W R416 24 2W R417 27 2W R419 27 2W R420 24 2W R422 24 2W R423 27 2W R425 27 2W R426 24 2W R428 24 2W

R415 36 2W R418 33 2W R421 36 2W R424 33 2W R427 36 2W

S401 REAR

COMPONENTS WITHIN DASHED LINES ARE LOCATED ON ATTENUATOR CIRCUIT BOARD

POS. PULSE Z_o: 50Ω

S401 FRONT

W13 POS PULSE OUTPUT 0.1US/CM 1V/CM

DO NOT MIX PULSES OF OPPOSITE POLARITY GREATER THAN 10V AMPLITUDE

NEGATIVE OUTPUT AMPLIFIER

-25V

CR287 CR288 CR289

...285 TO CR289 ARE DP19 1/1N4002

NOTE: C257-261, 287-291 ARE FACTORY ADJUSTED VALUES AND MAY OR MAY NOT BE PRESENT

R290 6.8 10% C287

R292 6.8 10% C288

R294 6.8 10% C289

R296 6.8 10% C290

R291 1.8K 10%

R293 1.8K 10%

R295 1.8K 10%

R297 1.8K 10%

R298 1.8K 0%

C291

ADJUST FOR MIN OVERSHOOT AT NEG. OUTPUT

R302 1K 0.2W

R301 1.5K

R303 680

R300 1.5K

R305 220 5%

TP12

Q59 SM1330 2N2270

R304 100

-5V

C294 100UF 35V

C295 0.1 75V

Q54 Q55 Q56 Q57 Q58

W12 PAD 0 0.1US/CM 5V/CM

DECREASE

BRIDGE "T" PAD

R440B 50 2W

R441 51 2W 5%

R440A 50 2W

R442 51 1/2W 5%

NEGATIVE

AMPLITUDE WITH 50Ω TERMINATION

VOLTS

1.2 0.4 4.0 1.2 1.2 0.4

R443 24 2W R445 24 2W R446 27 2W R448 27 2W R449 24 2W R451 24 2W R452 27 2W R454 27 2W R456 24 2W R458 24 2W

R444 36 2W R447 33 2W R450 33 2W R453 33 2W R457 36 2W

S402 REAR

- R414-428 ARE 5%
- SWITCHES ARE SHOWN IN EXTREME CCW POSITION
- ARROW ON ROTOR BLADE INDICATES CLOCKWISE ROTATION
- R443-458 ARE 5%

W14 NEG. PULSE OUTPUT 0.1US/CM 1V/CM

NEG. PULSE Z_o: 50Ω

S402 FRONT

S201	S402	S202 400
Q26	Q59	
CR201	CR289	
C201		
R201	R458	

J 40000-043

LD	LAST USED	OMITTED	ASSOCIATED DRAWINGS USED ON
REFERENCE DESIGNATION (701-490)			APPLICATION

SCHEMATIC — OUTPUT CIRCUITRY

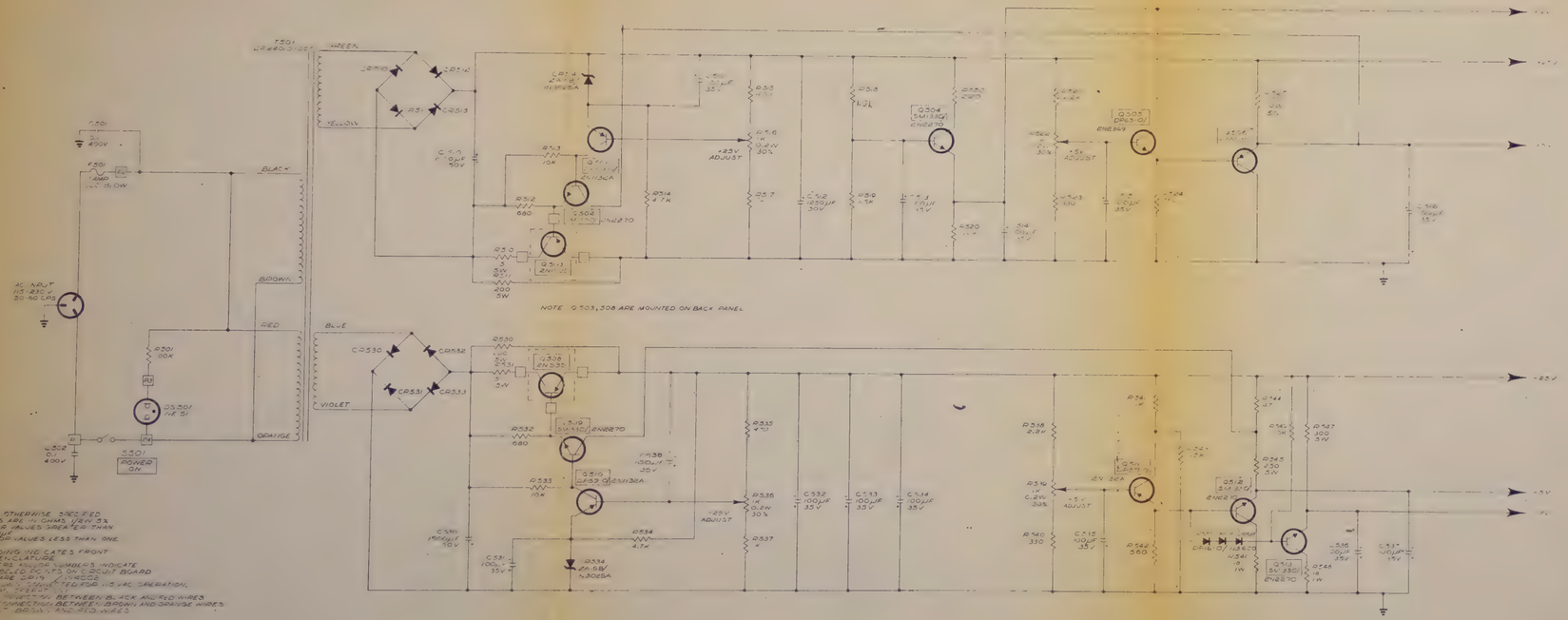
MODEL 106A

EATON-LEE RESEARCH INC. WALNUT, CALIFORNIA

40000-042 F

REVISIONS

LTR	DASH	DESCRIPTION	DATE	APPROVED
06	A	SEE E.O. 114	7/1/65	B Smith
19	20	E.O. 120 - C.S.		
43		... DWG #3154		
104	C	(1) ADDED BEAD TO EMITTER OF Q33 (2) ADD RESISTOR TO PROG. PCB (3) R241 CHANGE TO 1% TOL.	7-30-68	B Smith
324		(1) DELETED CR241 (ADD REPLACE WITH R274, PCB) (2) DELETED: H, DELETED: C238 S1 AT 284: (1) 5491-A WAS 5804 (2) R470 11.8K WAS 12K (3) ADDED BEAD TO EMITTER Q39		
376		B) Q48, Q50 Q51, Q52 Q53 ARE 2N4036 INSTEAD OF 2N4058 B) Q49, 13 2N4037 WAS 2N4-0 (4) Q47, 12 2N1132 WAS 2N2837		
328				
443	D	1) R22 K WAS 1.5K 2) R204 1K WAS 1.5K 3) SEE E.O. 469 4) ATTEN PC-1 REDRAWN	4-MAR-69	B Ross
469				
474				
4-1206	E	1) ADD NOTE 11 (FERRITE) 2) R260,262,264,266,269 R261,263,265,267,268 WAS 68Ω 3) ADD FERRITE BEADS TO BASE OF Q48-Q58 4) CR255-259 & 285-289 DP19-1/1N4002 WAS A200 5) Q48-60 (48-53 SWAMI) EMITTER WERE SM1415 W/OPT SM1330/TX2570 WAS SM1350	25 FEB 69	
1036				
4-43	F	REVISED SEE ECN 1043	6-MAR-69	



NOTES: UNLESS OTHERWISE SPECIFIED
1. ALL RESISTORS ARE IN OHMS, 1/8W 5%
2. ALL CAPACITOR VALUES GREATER THAN ONE ARE IN MFD
3. ALL CAPACITOR VALUES LESS THAN ONE ARE IN MFD
4. ALL SWITCHES ARE SHOWN ACCORDING TO MFG'S STANDARD SCHEMATIC NOMENCLATURE
5. ALL CIRCLED LETTERS AND NUMBERS INDICATE TERMINAL SOLDER POINTS ON P.C. BOARD
6. ALL DIODES ARE 1N914 OR EQUIVALENT UNLESS OTHERWISE SPECIFIED
7. T501 IS WIRED FOR 115 VAC OPERATION, FOR 230 VAC OPERATION:
   1. BREAK CONNECTION BETWEEN BLACK AND RED WIRES
   2. BREAK CONNECTION BETWEEN BROWN AND ORANGE WIRES
   3. CONNECT BROWN AND RED WIRES

DATAPULSE
DIVISION OF DATAPULSE INCORPORATED

SERVICE BULLETIN NO. 1-65

SEMICONDUCTOR REPLACEMENTS

(Applicable to all Datapulse Models except the Model 100 & 102)

Datapulse makes extensive use of house labeled semiconductors, superseding or used in place of commercial equivalents. In most cases, these are procured against relaxed or actual commercial equivalent specifications, and commercial equivalents as listed below may, therefore, be used as replacements.

	DATAPULSE TYPE NO.*	DATAPULSE PART NO.	COMMERCIAL EQUIVALENT
Diodes:	DP16-0	22164-000	1N3600
	DP16-1	22164-001	1N3604
	DP19-0	22194-000	1N2070
	DP19-1	22194-001	1N4002
	DP19-6	22194-006	1N2071
Transistors:			
	DP43-0	22435-000	2N984
	DP46-0	22465-000	2N964A
	DP46-1	22465-001	None**
	DP59-0	22595-000	2N1132A
	DP60-0	22605-000	2N2411
	DP60-1	22605-001	None**
	DP60-2	22605-002	[redacted] 2N3133
	DP60-3	22605-003	2N2894
	DP60-4	22605-004	2N3209
	DP60-5	22605-005	FT1702
	DP60-6	22605-006	2N3640
	DP63-0	22635-000	2N2369 or 2N2501
	DP63-1	22635-001	None**
	DP63-2	22635-002	None**
	DP63-3	22635-003	[redacted] 2 N2368
	DP63-4	22635-004	2N3646 3605 or ME9021

*Some earlier publications show Type No. without the dash.

**DP46-1 is selected from 2N2964A for high Beta.
DP60-1 is selected from 2N2894 for high Veco.
DP63-1 is selected from 2N2218 for secondary breakdown characteristics.
DP63-2 is selected from 2N914 for tighter Beta tolerance.

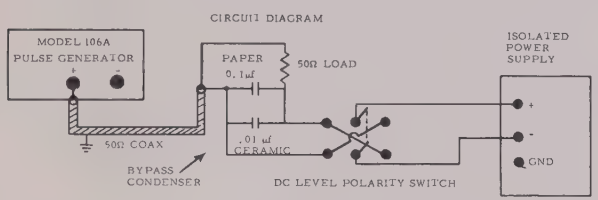
Replacements for these items should be procured from Datapulse.

[redacted]
11/18/65

USE OF A MODEL 106A PULSE GENERATOR AT A DC LEVEL BASELINE

DATAPULSE Model 106A Pulse Generator has a current source output, and it is often desirable to drive this output into a load which is returned to a positive or negative DC level.

The following demonstrates the feasibility of this application.



Results for Positive Pulse with Negative DC Voltage. At zero volts baseline the output circuits of the 106A are adjusted to give a controlled saturation of the output transistors (Q42 through Q46) by adjusting R272 for positive output. As the DC level goes increasingly negative, the initial baseline shifts with the DC level and draws the output pulse out of controlled saturation, thus increasing the overshoot (see Figure 1).

POSITIVE PULSE WITH NEGATIVE DC VOLTAGE

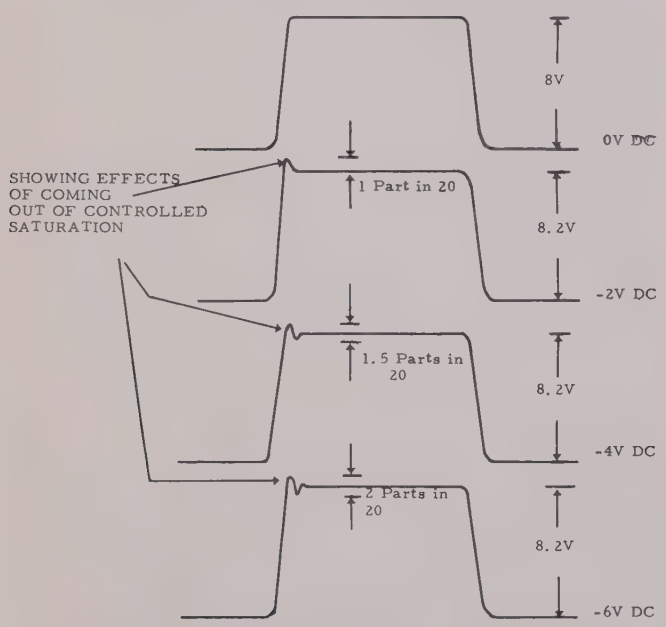


Figure 1. Model 106A Output Pulse Varying on the DC Level of the 50 Ohm Load Return (baseline).

Oscilloscope: Tektronix Type 543 with Dual Trace Amplifier.

Results for Positive Pulse with Positive DC Voltage. At zero volts the pulse generator is adjusted to give controlled saturation of the output transistors (Q42 through Q46) by adjusting R272. As the DC level goes increasingly positive, the upper levels are clamped by saturation of the output transistors while the lower level corresponds to the DC voltage (see Figure 2). When the DC voltage is the same as the polarity of the pulse, the voltage (top of the pulse) is clamped by the collector to base diode, and the output transistors, along with Q47 and Q59, must withstand the overdrive saturation currents.

POSITIVE PULSE WITH POSITIVE DC VOLTAGES

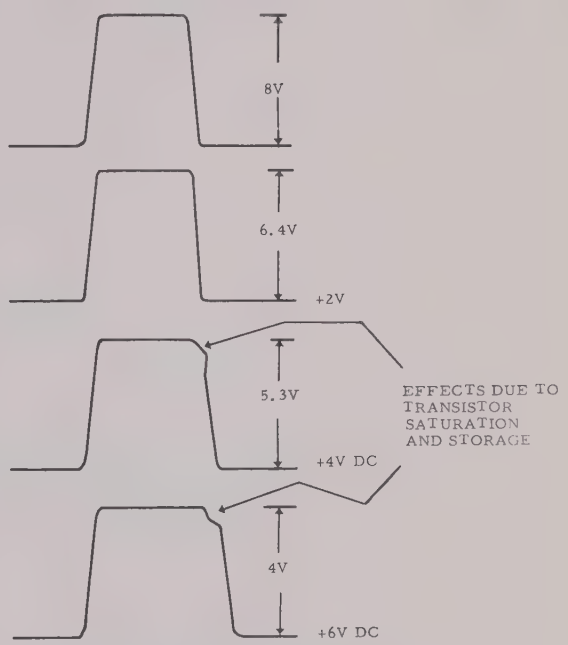


Figure 2. Model 106A Output Pulse Varying on the DC Level of the 50 Ohm Load Return (baseline).

Oscilloscope: Tektronix Type 543 with Dual Trace Amplifier.

Results for a negative pulse with a positive voltage will be similar to those achieved for a positive pulse with a negative voltage; results for a negative pulse with a negative voltage will be similar to those achieved for a positive pulse with a positive voltage.

Care should be taken to prevent DC voltages or transients from surpassing 8 volts in the direction opposite the pulse.

When the DC voltage is opposite the pulse polarity, voltage from collector to base of the output transistors should not exceed 20 volts. Q47 or Q59 will be destroyed if this voltage is exceeded.

Note 1: Model 106A Pulse Generator output has been specified for operation around ground potential and DATAPULSE is not responsible for damage to the instrument when operated at a DC potential. This mode of operation is being studied with a view toward a report on limits of reliability. If the generator must be used in this manner, it is wise to reduce the output with the attenuator to less than 8 volts.

Note 2: Until we have investigated the circuits for reliability under all conditions and if the customer must use the pulse generator under these conditions, it would be wise to make certain at least some of the attenuator or the Bridged "T" pad is reducing the output amplitude from its maximum value.

APPLICATIONS BULLETIN

NO. 106-3

ADDITION OF CAPACITOR DECREASES DELAY JITTER TO 0.01% ON MODEL 106A

Model 106A Pulse Generators, Serial Nos. 487 and earlier, typically provide delay jitter of 0.04% -- much less than the 0.1% specified in Technical Bulletin 106A.

Delay jitter can be further decreased (to 0.01%) for applications requiring ultra-low jitter, by the addition of one 100 μf capacitor in the -25v power supply.

Serial No. 488, and Serial Nos. 544 and subsequent will be equipped with this modification; however, modification of units already in the field can be accomplished by observing the following instructions:

Reference: Power Supply Schematic, Drawing No. J40000-043, and following sketch.

Parts Required: Capacitor, 100 μf, 35v, DP Part No. 11161-107, Nashville Part No. 20-500BP100-35585.

Insert Capacitor (Ref. Des. C538) between base of Q510 and -25v. (See sketch.)

a. Drill PC board and install four eyelets, two of which are side by side and make contact. Install one of the remaining two through the edge of Q510 base etching (back of board). The remaining eyelet should be inserted through the -25v etching.

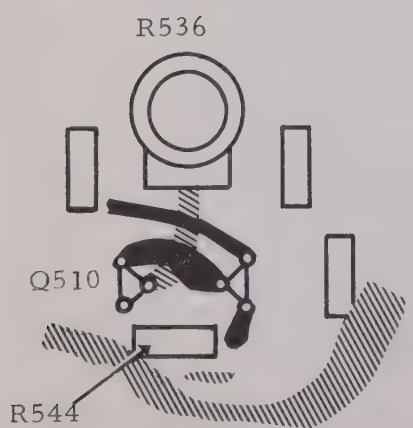
b. Re-position R544 47 ohm resistor as shown.

c. Note: Negative side of capacitor should be connected to -25v.

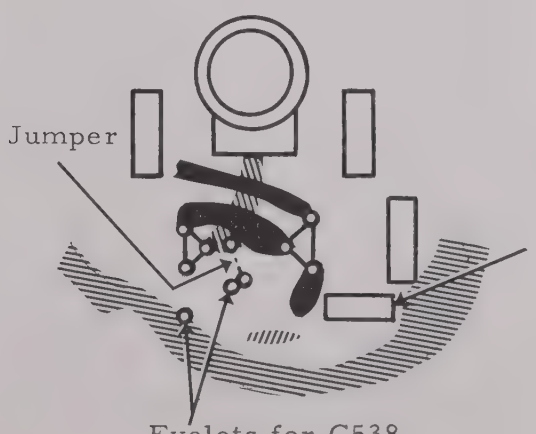
d. Install jumper as shown in sketch and solder.

Etched on Front of Board

Etched on Back of Board



Circuit Board at Q510
Before Modification



Same Area After
Modification

INSTRUMENT CERTIFICATION

MODEL 106A SN 815

1. Repetition Rate
   a) Internal
      Coverage: 10 cps to 12 mc
      Vernier: No holes
      Accuracy: Full scale of each range is accurate to within ±7%

   b) External
      Triggers from ±5v pulses 0 cps to 12 mc
      Triggers from 4v rms sine wave from 10 cps to 12 mc
      Single Pulse pushbutton gives one cycle of output for each depression

   c) Gated Operation
      Signals more positive than -1v block output

2. Sync Output

   Sync Amplitude greater than 5v into 100 ohms from 10 cps to 12 mc

   Amplitude is greater than 5.5 v into 100 ohms from 10 cps to 12 mc

   Amplitude is greater than 5 v into 100 ohms from 10 cps to 4 mc

   Amplitude is greater than 3.8 v into 100Ω from 4 mc to 12 mc

3. Pulse Delay

   Coverage: 40 ns to 5 ms
   Vernier: No holes
   Accuracy: Full scale of each range is accurate within ±7% except 50 ns point

4. Pulse Duration

   Coverage: 25 ns to 5 ms
   Vernier: No holes
   Accuracy: Full scale of each range is accurate to ±7% except at 25 ns point

5. Main Pulse Output

   Amplitude is 12 v ± 5%

   Positive Pulse

   Negative Pulse

   Transition Time

      Coverage: 10 ns to 1 ms

         Leading Edge

         Lagging Edge

      Vernier (no holes)

         Leading Edge

         Lagging Edge

   Waveform aberrations are less than ±4% at amplitudes greater than 300 mv

      Positive Pulse

      Negative Pulse

6. Double Pulse

   Coverage: 10 cps to 12 mc

      Positive Pulse

      Negative Pulse

I CERTIFY THAT THIS INSTRUMENT MEETS THE ABOVE SPECIFICATIONS

Test Inspector

12/22/65

Date

Q. C. ACCEPTANCE	
INSPECTOR	DATE
	12-22-65

WARRANTY

Datapulse Incorporated warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this Warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to making good at our factory any part or parts thereof except tubes, transistors, fuses or batteries which shall, within one year after making delivery to the original purchaser, be returned to us with transportation charges prepaid, and which our examination shall disclose to our satisfaction to have been thus defective.

Instruments returned under this Warranty will not be accepted at the Datapulse plant without prior authorization by a Datapulse representative or by the service manager of Datapulse Incorporated.

Datapulse Incorporated reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

This Warranty is expressly in lieu of all other obligations or liabilities on the part of Datapulse Incorporated and Datapulse Incorporated neither assumes nor authorizes anv other person to assume for them any other liability in connection with the sales of Datapulse Incorporated instruments.

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